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SOILS, CHEMICALS, IRRIGATION, ENGINEERING AND ECONOMICS

VOLUME 9, No. 6 JUNE 1957

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WORLD CROPS

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Here are the results of trials with 'Tetram' on different crops all over the world.

United Kingdom—*Apples*

Over 200 acres (81 hectares) in 20 orchards were sprayed. The best time to apply is at the second post-blossom spray (mid-June). In one trial only 3 mites per 100 leaves survived in September, compared to 1,000 survivors with a standard ovicide.

South Africa—*Apples, Pears*

Four months' control of red spider and Bryobia mites *Bryobia praetiosa* and *Amphitetranychus viennensis* obtained with less than 1 oz. in 100 gallons (6.25 g. in 100 litres) of water.

U.S.A. (Texas)—*Cotton*

One application of 3.2 oz. per acre (224 g. per hectare) destroyed all red spider mite in 24 hrs. No re-infestation for 7-8 weeks.

U.S.A.—*Scale on Citrus*

One application per year gave economic control. High volume applications of 200 parts per million at rates up to 2,500 gals. per acre (28,000 litres per hectare) for fully grown trees. For young trees low volume spraying at 500 parts per million gives control, gallonage according to size of tree.

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'Tetram' 75	:	U.S.A.
'Metramac'	:	Sweden, Norway, South Africa, New Zealand, Japan and Portugal
'ICI' Amiton	:	Holland
'Inferno'	:	Italy

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Editorial Comment

Asia in a hurry

I heard a sound of running feet,
And all along the dusty street
A multitude came sweeping by.
On every shoulder was a load;
Each drove his neighbour with a goad;
I saw one stoop and heard his cry:
' Why drive ye in this dreadful race?
Why urge ye such an awful pace?
What treasure do you look to find?'
They turned upon him in amaze
And gaped at him with owlish gaze,
And suddenly I saw them—blind!
' Where to?' ' We neither know nor care!'
But hurry, hurry onward there!
That multitude was called—Mankind.

Colwyn Philipps.

The Prime Minister of Ceylon, the Hon. S. W. R. D. Bandaranaike, addressing the annual general meeting of the Planters' Association of Ceylon, gave the assurance that ' nationalisation of land was the last item of a long list of nationalisation projects which the Government had in view '. This means that, although wiser councils have prevailed, the respite is only temporary—the nationalisation of the tea, rubber and coconut industries can therefore be considered a certainty.

' Asia is in a hurry ', says Sir Percival Griffiths, writing in the *Daily Telegraph* (25 March, 1957). ' In the south and south-east of the continent, where self-government is a new and stimulating experience, the Asian peoples are in a hurry. In India and Pakistan the sense of urgency is palpable, while the easy-going Burmans and the unpractical Sinhalese feel that they have lost a few centuries and must now catch up'.

'Being in a hurry, they are not prepared to trust to haphazard processes. They have adopted, without reserve, the principle of national planning. No politician can cast a doubt on this philosophy of national planning without being dubbed a reactionary '.

The planners soon find themselves faced with difficulties. First national planning inevitably means a terrifying network of government controls, not as emergency measures, but as a permanent feature. The second difficulty in Asia's hurry is caused by economic nationalism. A newly self-governing country insists that the ownership of important industries should be in national hands; that the foreigner should be restricted to certain spheres of industry in which the people of the country cannot really operate; and that foreign personnel in superior posts in agriculture or industry should be replaced by nationals—*whatever the consequences*. Each of these aspirations is understandable, but they conflict with the desire for rapid progress.

In Pakistan over-haste has produced two serious financial crises. Ceylon, with her very profitable tea industry, has escaped economic collapse only by the wise though chilling counsel of the International Bank. Today most of the countries of south and south-east Asia are being generously assisted by external aid—up to June 1956 the Asian Colombo Plan countries have received aid from the West, in one form or another, of no less a sum than £850 million, in addition to loans of £128 million from the International Bank. More recently the demand for foreign aid has taken the form of requests for long-term credits.

According to Sir Percival, ' Progress in the few years of independence has already been impressive, except where political instability or administrative weakness has stood in the way . . . in Ceylon economic nationalism and doctrinaire Socialism count for too much . . . '

Meanwhile, Imperial Russia is watching. The visits of Kruschev and Chou-en-lai to India and Ceylon, already forgotten in the rapid helter-skelter of political events, were not without tremendous significance to Asia and to the whole world. Remorselessly and with calculated design the Communists are working for the total economic collapse of south and south-east Asia. Out of the ashes of the British, Dutch and French empires will then rise like a phoenix the spectre of a new colonialism—*the domination of Imperial Russia.*

The unthinking do not stop to consider what will be the consequences to their country of the deterioration of their planting industries, which must be the inevitable consequence of bureaucratic control; they do not know, or they forget, what happened in Russia itself after the landowners were dispossessed of their lands—the majority of the *Kulaks* were liquidated and millions died in the famines which followed the nationalisation of the prosperous farming industries. So, too, will it be in south-east Asia, but on a far vaster scale, unless the pace can be slackened. ' It can't happen here ', it is often said—can't it? It is already happening, but Ceylon may still save itself from national disaster if wiser counsels are allowed to prevail.

People in all the newly-self-governing territories need to be alerted to the fact that Communism is the new Nihilism; its inflexible purpose is the economic destruction of the world in order to establish their ideal new world. But it does not follow that in fact such change would be for the better on social considerations alone. The only thing certain is that death and disaster on a vast scale would be inevitable.

Sucro-crystallography

SUCROSE shares with common salt the unique distinction of being both a food and a crystalline chemical. Both are consumed in enormous quantities, and according to Mr. H. E. C. Powers, Chief Chemist of the Thames refinery of Messrs. Tate & Lyle, the world uses some 40 million tons of sucrose per annum. Addressing the Food Group of the Society of Chemical Industry recently, he expressed the view that whether he is concerned with the production or with the utilisation of sugar, the technologist needed to have some knowledge of crystal characteristics, because the physical condition of the sucrose affects its utilisation. Spray-dried sucrose is quite a different product from crystalline sucrose; small crystals below 1μ in size are more easily soluble than large crystals; dendritic, irregular or conglomerate crystals are difficult to clear of syrup, and in some cases the syrup is occluded within the crystal.

The ruthless one

IN the fight against the locusts in the Sudan the Sudanese locust control has used up 7,750 tons of poisoned bait and employed an extra 350 vehicles in work which may influence the effect of locusts on East Africa later this year.

The Director of the Desert Locust Survey has said that this was international work of direct benefit also to East Africa and may settle whether or not East Africa got locust swarms towards the end of this year.

According to Dr. R. C. Rainey, of the Desert Locust Survey, the basic problem of locust control is one of dealing, at source or subsequently, with large, mobile insect populations, at times of the order of 100,000 tons of locusts, travelling distances often of the order of 1,000 miles in a few weeks, and each with a daily food consumption of the order of its own weight of plant material. For effective control the main operational effort has accordingly to be made hundreds of miles outside the crop areas to be protected, under conditions often severely restricting the choice of control materials and methods.

The desert locust, unlike other important swarming species, has no restricted, permanent outbreak areas lending themselves to continuous supervision and control (ecological or chemical) by a small, static organisation; and swarms are always to be found somewhere within the 11 million square miles subject to invasion, of which a total of at least 400,000 square miles experiences breeding by swarms during 50% or more of years.

The Locust Control Committee for Eastern Africa has just set up a permanent secretariat in Addis Ababa with funds provided by FAO. It will co-ordinate and assist locust work throughout Eastern Africa—the Sudan, Ethiopia, Somaliland Protectorate, French Somaliland, Somalia and Kenya.

Paper from sugar-cane

FOR every ton of sugar extracted from the cane a ton of fibrous residue, known as 'bagasse', is left. It is generally treated as a waste product and burnt in the boilers for raising the steam needed for processing the sugar.

Now, according to the U.S. Department of Agriculture, it could be used as a raw material for the production of pulp for paper-making and could also help to relieve the shortage of newsprint, as the potential world supply is immense and is estimated to be 25 million tons per annum.

A process has been developed by the Agricultural Research Service at the Northern Utilisation Branch Peoria, Ill., whereby the fibres are separated from the pith; the pulp so obtained is suitable for the production of fine bleached papers, stationery and packaging materials, as it is stronger in all but resistance to tearing than the softwood pulps produced by the acid sulphite process. It is claimed, too, that this 'mechano-chemical' process gives higher yields of high-grade pulp at lower cost. Bagasse pulps are especially suitable, it is said, for blending with other wood pulps for making a wide variety of paper products.

The absorbent pith, too, is finding a use as a carrier for molasses to produce a solid, easily transportable high-energy feed for cattle. The potential market for waste black molasses, which is relished by cattle, is estimated to be nearly a billion* gallons a year.

In Louisiana and Florida, where 900,000 tons of bagasse are produced annually, a considerable amount goes into making wallboard; some is also processed into poultry litter, and there are considerable possibilities, as some 14 million tons of all types of litter are used annually in the U.S.A. A paper mill in Louisiana is already producing between 20,000 and 25,000 tons of newsprint annually from bagasse.

Cattle in India

THE number of cattle in India is reckoned to approach a total of 200 millions, a figure which may be correlated with a population of 400 million souls and a gross sown area of 330 million acres, of which 85% is planted to food crops.

The average yield of milk per cow in India is said to be 410 lb.—the lowest in the world—compared with averages ranging from 2,000 to 7,000 lb. in other countries. Only about one-sixth of the cattle yield any milk and one-fifth are useless for any purpose, except for producing dung, which is collected, caked and dried for use as a fuel.

The consumption of milk and milk products in India is below half the desirable level, even though milk is the main source of animal protein for most Hindus.

One of the early shocks an agriculturist has on visiting India is the general low standard of the cattle.

*1 billion = 1,000 millions.

Herds roam, apparently at will, over the sparse pastures, scavenge in the bazaars, and interbreed at random. Grazing is usually of short duration, for when the monsoon arrives all possible land is ploughed and planted.

Cattle in India can do well, as the military farms in the Punjab bear witness and the agricultural stations have repeatedly demonstrated. When an Indian cow is crossed with an Ayrshire, for instance, the milk yield is increased tenfold or more, but bulls from such crossings have small humps, which characteristic reduces their value as draught animals. Nevertheless, other crosses with humped types produce suitable draught animals and good milkers.

But the cow is sacred in India and any interference with it is resented by the majority. It may not be killed, its meat may not be eaten and strict Hindus even refuse to touch leather made from cowhide. Yet the poor beast is usually short of feed and when used as a draught animal may be treated in a most brutal manner. Meanwhile, the herd increases and deteriorates, more grazing land is constantly sought, more Indians go undernourished and more food has to be imported. *The whole set-up regarding cattle in India is impossible to reconcile with conditions in the world of today.*

As previously reported in WORLD CROPS (1957, **9**, 52), there was a startling rise in milk production in Russia when the number of milk cows was reduced to adjust the cow numbers to the fodder available. To the Western mind, it is incomprehensible that this cannot also be done in India; the nearest approach has been a suggestion that surplus animals could be bought up and driven into the desert—an idea which fills us with horror.

There is no doubt that disaster lies ahead if nothing is done. Through over-grazing the pastures never get a chance to recover and the fertility of the soil will deteriorate until extreme desert conditions are established owing to the total destruction of all ground vegetation and the total disappearance of organic matter in the soil. A research possibility which merits consideration is the use of controlled atomic radiation or some form of veterinary treatment to reduce or control the rate of reproduction of these pathetic animals. It would, however, be necessary to compensate the owners, as the cow is almost the sole possession of the villager.

Salt and soil

IT is quite possible to overlook the important relation between the mineral constitution of a soil and its physical structure. Only when the mineral balance has been so seriously upset that the soil structure is in danger of breaking down does it appear imperative to apply minerals for the specific purpose of restoring good soil texture.

Such a situation has arisen in large areas of Essex, where, in the winter of 1953, 41,000 acres of farmland were inundated by the sea. On some parts the sea water remained for several weeks and left behind from 20 to 30 tons of salt per acre. The effect of this salt was to displace the calcium contained in the soil by sodium and the cure was to reverse this substitution.

The application of two tons per acre of calcium sulphate, combined with good drainage, has given promising results. Alternatively, the land was left fallow or drained, but in either case recovery was slow and premature attempts to crop previously flooded and untreated land have led to poor results; it will be many years before this soil will be restored to its former condition.

Diagnosis by subtraction

INCREASING attention is being given to the use of fertilisers in tropical agriculture. Following former European practice, attention has for far too long been focused on nitrogen, phosphorus and potash, singly or in combination. Only in recent years have the remaining nine or 10 elements known to be essential for plant growth begun to receive attention.

This preoccupation with NPK has tended to restrict thought and experimentation, and the result of the applications of these ' major ' elements at various levels and in various combinations, under various conditions, have sometimes been conflicting and inconclusive. Responsible planters, too, have complained that the response to the application of such fertilisers has been disappointing in that, after a period during which responses are spectacular, yields begin to fall off.

The evidence of the widespread incidence of ' minor ' element deficiencies, taken in conjunction with the indications of the magnitude of their possible effect on crop yields, serves to emphasise that the approach to the problem of fertiliser trials, at least in the tropics, needs broadening, according to R. A. Webb, of the A.R.C. Unit of Plant Nutrition, Long Ashton, in his address to the Agriculture Group of the Society of Chemical Industry in the course of the symposium on ' Trace Elements in Soils, Plants and Animals '.

Experiments have shown that major element responses can be limited drastically by trace element deficiencies and vice versa, and it is possible that the lack of response to the application of a particular element can be due to another simultaneous deficiency in the soil. One is faced, therefore, with the necessity of testing a large number of mixtures of increasing complexity, but for diagnostic purposes such a procedure would be too unwieldy.

He concluded that if a reasonably balanced *complete* fertiliser, containing all the known essential elements, were used as a standard, comparisons might be possible between the response to the complete fertiliser and responses to deficient mixtures prepared by omitting each element in turn from the complete mixture. He called this the ' subtractive ' method.

Multum in parvo

A REPORT of the proceedings of this conference will appear in the July issue of WORLD CROPS. The discussions reached a very high level and showed that workers in this difficult field of research have gone a long way towards determining the role of trace elements in the nutrition of plants and animals. The farmer, the planter and agriculturists are primarily concerned with the application of the results of these researches in agriculture.

A film, which was shown to the members attending the conference, showed how important fundamental research in this field is likely to be for the future welfare of mankind. Even though some of these minor elements are only required to the extent of a few ounces per acre, this trace can make all the difference between success and failure in the production of agricultural crops.

The film—' The Pumice Lands '—showed how the useless and infertile fern and tussock country of the central plateau of North Island, New Zealand, has been converted into green pastures. The soil was of the right physical texture, but was short of two essential nutrients—phosphorus and cobalt—the latter being required to the extent of only 2 or 3 oz. per acre.

The rehabilitation of these ' badlands ' was organised as a combined operation by the Government. First, 200 miles of roads had to be made and electric power brought to the area; then the coarse brushwood and vegetation was smashed down with heavy, spirally-fluted rollers; the debris was burned and any irregularities in the land were smoothed out with bull-dozers. After ploughing and harrowing, the two fertilisers and pasture seed were applied from the air and the settlement of the area was begun.

In the March issue of WORLD CROPS there was an account of a similar operation in the 90-mile desert of South Australia, where life was given to the land by the use of zinc and copper, also applied in trace amounts, as a result of which land values increased from A£1 to A£25 per acre. Elsewhere the application of phosphorus and molybdenum and the introduction of subterranean clover into the pastures have resulted in twofold to threefold increases in productivity.

Trace element deficiencies are also becoming increasingly evident in the U.S.A., where over 35 areas are reported to be deficient in molybdenum. This element plays a part in the reduction of nitrates to nitrites and in plants suffering from molybdenum deficiency it has been found that the concentration of nitrates becomes unusually high. Work done by D. Spencer and J. G. Wood in Australia has shown that when molybdenum is applied to molybdenum-deficient tomato plants there was a marked increase in the level of nitrite and ammonia and later in the level of amino acids and proteins, with an accompanying decrease in the nitrate level.

The status of molybdenum in agriculture and the possibility of reclaiming land in the Hawaiian Islands has been reported by G. S. Cripps. Webb, too, in the paper which he presented at Bristol gave an account of deficiencies of boron, copper, manganese, molybdenum, zinc and iron which had been found in major crops in various tropical countries.

Farms or forest

ONE of the best reports upon land use in Britain has come from the Natural Resources (Technical) Committee—' Forestry, Agriculture, and Marginal Land '.* Can a country so thinly endowed with natural resources as Britain afford to neglect so much of its land, even though it may be classified as marginal, be remote from modern services, sited on hills, or of low fertility? Need all the land now arbitrarily classified as marginal remain marginal?

The Committee's principal suggestion is to put back the trees on our hills. Afforestation as well as agriculture is urged, with a bias towards trees for remotely-sited hill land and for more steeply-sloped hill land, whether remote or not. As the neglect of forestry in Britain is greater even than the neglect of farming of marginal land, there is much to be said for this dual policy, despite past evidence of incompatible rivalry between agriculture and forestry.

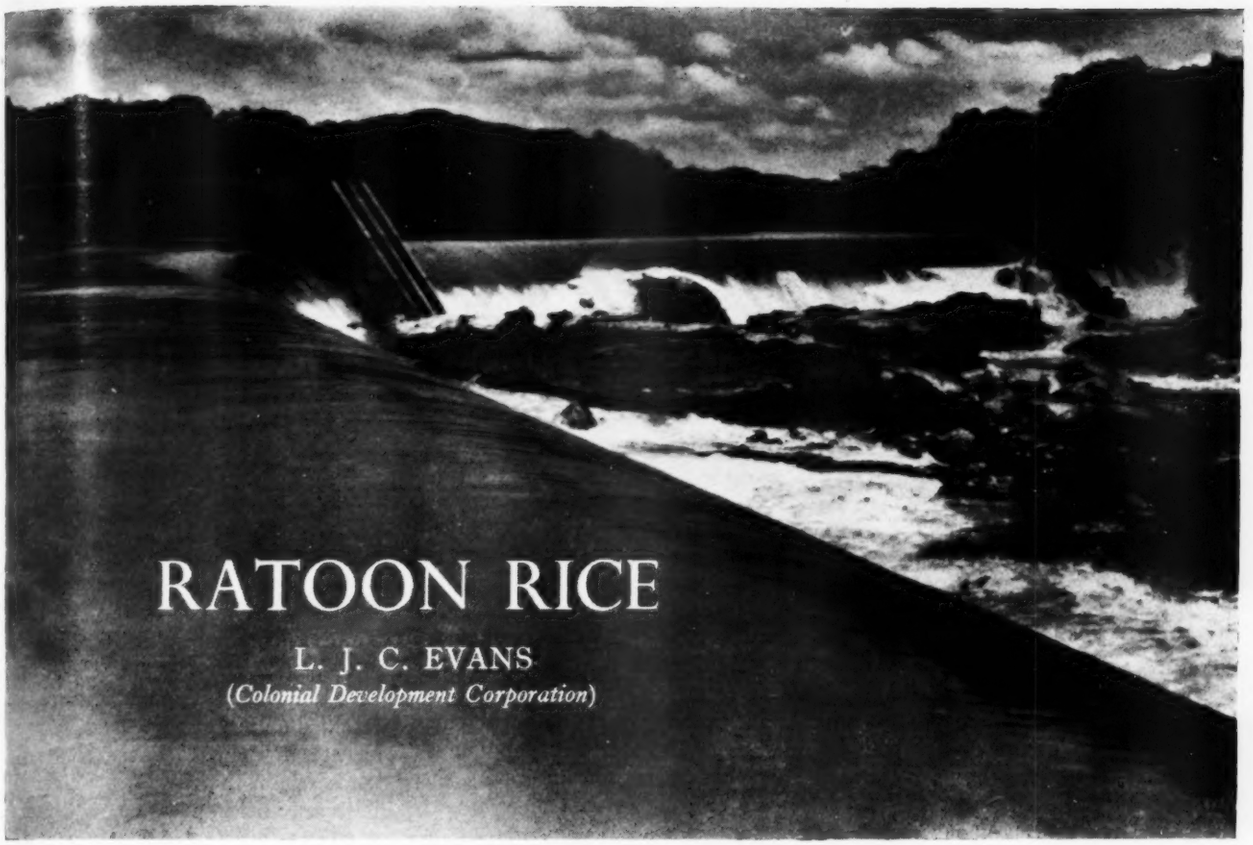
Upland grazing integrated with small plantations of pine or spruce would produce winter shelter for stock and forestry work could provide a partial occupation for agricultural workers during slack periods.

Whether marginal upland farming is to be given further encouragement or not, a bold policy of afforestation is obviously desirable. Climate and soils in Britain are said to be more favourable to tree growth than in the leading timber-producing countries of Europe. In Britain the rate of growth attainable is more than twice that in Sweden for pine, and nearly twice the Swedish rate for spruce.

However, less than 7% of our land space is under trees, whereas the corresponding figure in West Germany is 28%; in Denmark, 10.4%; in Norway, 24%; and in Sweden, 56%. The long-term nature of investment in trees and competition between forestry and agriculture for marginal land have both contributed to the neglect of a crop so naturally suited to our conditions.

The Committee's enquiries have shown that annual return from capital investment in afforestation is slightly better than the return from investment in marginal land farming, if new farm buildings are required for the latter. Perhaps even more vital, the import savings to be expected from afforestation are substantially greater than import savings through the farming of marginal lands on the hills. It can also be argued that the world today is even shorter of timber than it is of food.

* H.M.S.O. 4s.



RATOON RICE

L. J. C. EVANS
(Colonial Development Corporation)

Diversion weir in the Komati River

THE first stage of the gravity canal scheme, begun in 1955, is due to be completed in 1957. The diversion weir in the Komati River was actually completed before the end of 1956. Pending completion of the gravity irrigation system, irrigation water for rice growing has been provided by pumping from the Komati River on to some 2,000 acres of land which have been laid out on the north-east corner of the scheme. This followed a 200-acre pilot scheme which was laid out in 1951–52 based on experience gained in experimental trials.

Various aspects of the Swaziland Irrigation Scheme have been discussed in a previous issue (WORLD CROPS, 1956, **8**, 67). *A ratoon crop of rice may be grown either in the same year as the main crop or in the year following. In this article the two systems are compared.*

Previous system of ratooning

The system of taking ratoon crops of rice previously described (see introduction) involved planting the main crop during the spring or early summer months (September–October). After harvesting the main crop some four months later, the stubbles were flooded and a second crop was allowed to grow, and this was harvested about three months after the first crop. The growing period of the ratoon crop was shorter than that of the main crop, because its root system was already established. In this way two crops of rice were harvested in the same year.

Several difficulties in this particular system of ratooning have come to light. One of the difficulties is in the control of weeds. Unless the main crop can be harvested early—say January–February—the subsequent 'autumn ratoon' crop does not make satisfactory growth. For the main crop to be harvested early, it is necessary to plant it early, but planting as early as August–September does not allow sufficient time for the pre-sowing cultivations which are essential for weed control. These pre-sowing cultivations do not effectively control weeds if they are done prematurely. Until the seasonal rise in temperature is sufficient to induce germination and growth of weeds such preparatory cultivations can be a waste of time. Fields kept tilled through the winter months may look clean, but nevertheless may carry a heavy weed growth when summer comes.

Carrying out the pre-sowing cultivations at the right time means delaying the planting of the main rice crop for about a month. Planting can start in October–November, but this means that the majority of the crop is harvested too late for the subsequent autumn ratoon to make satisfactory growth. It may be possible to take autumn ratoons from those fields which are the first to be planted with main crop paddy, but autumn ratooning cannot be regarded as a satisfactory system for the majority of the planted area.

The new system

It has been found during the past two years that a much more satisfactory system of ratooning is not to follow the main crop immediately with a ratoon crop, but to allow an interval of about six months between harvesting of the main crop in January–February–

Work in progress on one of the siphons during construction of the main canal in the Swaziland Irrigation Scheme

March and the cultivation of a ratoon in the following spring. Under this system the main crop is planted in October–November after the fields have been flooded to promote weed growth, which is then disk-harrowed or ploughed under before the paddy is sown. The main crop is harvested in January–February–March, after which the fields are allowed to remain in stubble, without any irrigation, until the following spring.

When the spring rise in temperature occurs about August–September the stubbles are irrigated and the ' spring ratoon ' crop begins to grow, and is ready for harvesting about January.

Advantages and disadvantages

Under this system only two crops of rice are obtained in two years, a main planted crop in the first year and an unplanted spring ratoon in the second. The cost of the ratoon crop is appreciably less than that of the main crop because the ratoon does not have to bear the costs of land preparation and planting, and the ratoon crop needs about 20% less irrigation water than the planted crop. Yields of the main crop under good conditions are about 2,700–3,000 lb. paddy per acre; that of a good spring ratoon crop is about 2,300–2,400 lb. paddy per acre.

There are other advantages of ratoon crops besides lower production cost and lower requirement of water. If a proportion of the rice produced each year is derived from ratoon crops, less machinery, equipment and labour are required for land preparation and planting because these operations are not, of course, required in the case of a ratoon crop. Also on experience to date the spring ratoon crop seems to be relatively free from weeds and from self-sown rice.

There could, however, be some disadvantages associated with rice ratooning. The most obvious is that the taking of ratoon crops and leaving all stubble in the ground unploughed may allow a build-up of pest populations. There has been some indication that ratoon crops may be fairly heavily infested with rice stem borers, including *Ampycodes pallidicosta*, though so far the loss of crop, either in the main crop or the ratoon, does not appear to be considerable.

Pests

In addition to rice stem borers of several kinds, there has been loss of crop due to attacks by rice leaf beetle, *Trichispa sericea*. Serious damage was done to the 1954–55 rice crop by rice leaf beetles before the pest was brought under control by spraying with dieldrin.

Weeds

In common with most areas where rice is planted, rather than transplanted, weeds become a serious problem if rice is planted year after year in the same field without rotation. Rotation trials in Swaziland are under way, including trials not only of alternate winter and summer crops, but also of grazing by cattle. In addition to a considerable area of irrigable land, the Swaziland Irrigation Scheme has upwards of 60,000 acres of dry land suitable for ranching. The scheme at present maintains 8,000 head of cattle and plans to increase the numbers progressively. It is expected that integration of livestock and crops will then develop.

The worst weeds of the rice lands are, as is commonly the case, grasses, including *Echinochloa* species. Accurate levelling and water control are essential and so also is control of weed growth in drainage lines and reserve lands within the rice area. Herbicide trials are now in progress.

Varieties

When rice growing began on the Swaziland Irrigation Scheme a variety found in Natal, known as UVS, gave promising results. This was grown on a fairly large scale until it began to be replaced by the variety ' Blue Bonnet ', seed of which was imported from the U.S.A. in 1954. ' Blue Bonnet ' is now providing satisfactory crops both from main crop and ratoons and the quality is popular locally.

Using a self-propelled combine-harvester for harvesting rice

SUGAR-BEET GROWING IN THE U.K.

D. C. G. THOMSON, B.SC.

(*Agricultural Development Department, British Sugar Corporation Ltd.*)

Sugar-beet is today one of the leading cash crops in Great Britain. An area of over 400,000 *acres produces an annual tonnage of between* 4½ *and* 5½ *million tons of beet, which is processed into the equivalent of between* 600,000 *and* 700,000 *tons of refined white sugar. In addition, approximately* 300,000 *tons of dried molassed sugar-beet pulp are produced and this, together with vast quantities of tops and crowns, are used as food for cattle.*

ALTHOUGH sugar-beet cultivation became firmly established in Great Britain only about 30 years ago, great progress has been made in the many aspects concerned with the production of this relatively new crop. Apart from the important addition to the national income, sugar-beet cultivation also helps to improve the soil, and the beneficial effects on succeeding crops obtained from the more intensive husbandry required by the beet crop—particularly deep ploughing and heavy manuring—has resulted in a great improvement in the general standard of farming. The by-products available encourage the grower to maintain stock on the farm, which again results in higher fertility of the land.

Research and education

In the early days advice to the grower was based largely on European practice, which was only to be expected considering that sugar-beet had been grown on the Continent for many years before its introduction to this country. In the following period, however, and particularly after the amalgamation in 1936 of all the existing 18 sugar factories to form the British Sugar Corporation, an extensive and expanding programme of research and education was carried out until, at the present time, over £70,000 has been earmarked for this purpose. The programme is administered by the Sugar Beet Research and Education Committee, which comprises representatives of the Agricultural Research Council, the Agricultural Improvement Council, the British Sugar Corporation and the National Farmers' Unions. The chairman of the committee is appointed by the Government and when required for dealing with technical questions representatives from the following research and other centres are also present: British Sugar Beet Seed Producers' Association, National Institute of Agricultural Botany, National Institute of Agricultural Engineering, Norfolk Agricultural Station, Plant Breeding Institute, Cambridge, Rothamsted Experimental Station, School of Agriculture, Cambridge, and the Scottish Society for Research in Plant Breeding.

Much of the field work is carried out by the agricultural staff of the British Sugar Corporation at the sugar factories, so that many of the experiments (*e.g.* variety trials) are conducted under the widest possible range of soil and climatic conditions in the areas where commercial beet crops are grown. The British Sugar Corporation also plays a prominent part in the educational side of the Research Committee's activities, the scope of which may be judged from the above list of research centres engaged on the many aspects of the work involved.

Increased yields

A measure of the tremendous progress made in sugar-beet growing during the past few years can be gauged from the striking increase in the yields obtained. The seven-year average yield (1950–56) is over 11¾ tons per acre, which compares with the average during the previous seven years of only 9½ tons per acre. The highest yield yet recorded was 13.1 tons per acre in 1953, the second highest (12.8 tons per acre) in 1950, and the third highest (12.6 tons per acre) was achieved last year. Apart from the effect of favourable climatic conditions, which it is practically impossible to assess accurately, these extraordinary increases in yield are without doubt the result of a combination of many factors, the more important of which may be summarised as follows: earlier sowing, improved varieties, more effective pest and disease control, higher plant populations and the use of heavier dressings of artificial fertilisers. Other advances made in recent years have also contributed to the higher standard achieved: for instance, seed treated with combined fungicide and anti-wireworm dressings and spraying for chemical weed control. Improvements in cultural practices and the accumulated knowledge and experience gained in growing the crop must also have a considerable influence. Examples of the latter are illustrated by the fact that at one time severe damage due to wireworm and crop failures, due to soil acidity, were fairly common, but losses from these causes are now comparatively rare.

For many years early sowing has been advocated as a means of increasing yields, as it was known that the sugar-

Two crops in one. Sugar is extracted from the root and the residual pulp and the tops and crowns are used as cattle feed

A modern four-unit precision drill (Stanhay) in use in Lincolnshire

beet plant requires a fairly long growing period to reach maturity under normal conditions in this country. The highest yields have nearly always been obtained in years when the crop was sown early—in the record years of 1950 and 1953 nearly 40% of the crop was sown in March, and this has confirmed the results of previous trials. Nowadays drilling of sugar-beet normally commences about the middle of March and under normal conditions most of the crop is sown by the middle of April.

Bolting

Sometimes progress in one direction causes additional problems and this applies in the case of early sowing, which tends to increase the percentage of ' bolters ' in the crop. Sugar-beet is a biennial plant, but under some conditions it produces flowering stems in the first year. This so-called ' bolting ' is undesirable because the roots of bolted beet are usually smaller, lower in sugar content and extremely tough, thus causing difficulties at harvest time, particularly when mechanical harvesters are used. The tendency to bolt is a varietal character and considerable progress has been made by plant breeders in recent years in producing varieties that are comparatively resistant to bolting. However, this is still a serious problem and the advantages of early sowing are so great that constant efforts must be maintained and, if possible, increased in order to reduce the bolting tendency.

Seed breeding

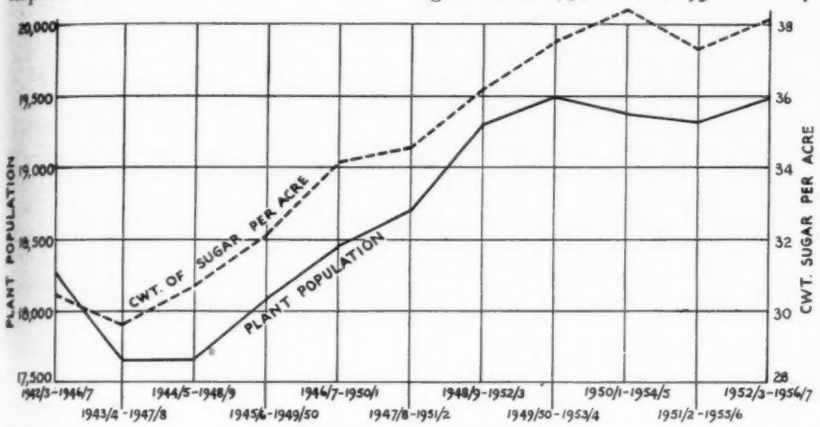
Before the last war most of the sugar-beet seed used in Great Britain was imported from the Continent, but as these supplies were eventually cut off, seed had to be produced in this country and the position is now completely reversed. Previously a larger proportion of ' N ' and ' Z ' varieties (which produce a higher sugar content and medium weight of root) was used, but now the ' E ' types, which tend to give higher yields and slightly lower sugar contents, are more popular. This again may account to some extent for the higher tonnages obtained in recent years. A development in seed breeding during the last few years has been the introduction of polyploid sugar-beet seed. Sugar-beet is normally a diploid plant, but by the application of new techniques triploid and tetraploid plants are produced which have given favourable results in some European countries where polyploid varieties are now widely used. In this country the breeding of polyploids is in its early stages and it is expected that good results will be obtained in due course.

Plant population

The effect of plant population on yield has been studied in numerous experiments carried out for many years and these have invariably proved the benefits of high plant numbers per acre. Although increases in yield obtained by raising the plant population varies according to climatic, soil and other conditions, there is no doubt that a high plant population is the best safeguard against poor yields, particularly in dry years or when pests and diseases are more prevalent. The graph shown opposite, reproduced from the *British Sugar Beet Review*, which records the progressive five-year averages for plant population and yield of sugar per acre, illustrates the close correlation between the two. The populations shown are the calculated number of plants delivered to factories and consequently are slightly lower than the plant numbers obtained in the field.

The general recommendation is to aim to leave 30,000 plants per acre, although this number is not often achieved in practice. The first essential for obtaining a satisfactory plant population is the production of a good even braird of seedlings without gaps, and this is probably the most critical stage in sugar-beet cultivation. Satisfactory emergence of beet seedlings is dependent on a number of factors, the most important being a fine, firm seed bed with an adequate moisture content. Methods of seed-bed preparation vary in different parts of the country, but generally there is a tendency towards less deep cultivations which help to conserve soil moisture and

produce a finer surface tilth. One-way ploughs, land levellers, wooden-framed harrows, tractor wheel extensions and other implements which assist in producing a level surface are becoming more widely used, and with the increase in subsequent mechanical operations on the crop the importance of obtaining a level surface cannot be overemphasised.



Plant population and increase in yield

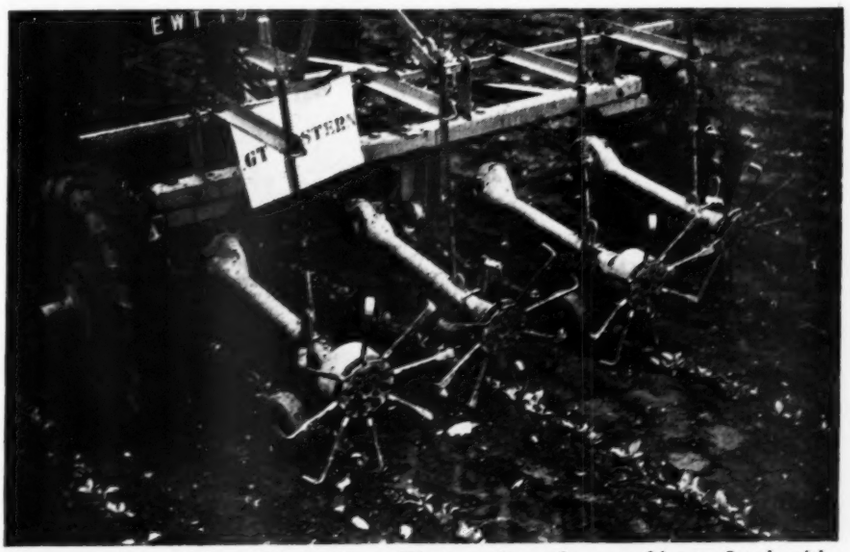
Pests and diseases

Losses due to pests and diseases in countries where beet growing had been established for many years caused the factories in this country to begin research work quite early in the life of the industry. Sugar-beet is no exception to other crops in being subject to a fairly wide range of pests and diseases and the most important of these are beet eelworm and virus yellows. Beet eelworm was first found attacking sugar-beet in Great Britain in 1934 in the eastern counties, although it had been discovered on mangolds in 1928. In order to prevent the spread of this malady, often called ' beet sickness ', which has had disastrous effects in other countries, the British Sugar Corporation, in agreement with growers, included a clause in the sugar-beet contract under which the successive planting of sugar-beet and related crops on the same land is controlled. When it became clear that more drastic measures were required, the Minister of Agriculture and Fisheries made the Sugar Beet Eelworm Order of 1943. This Order was revised in 1952 and is designed to prevent the spread of eelworm and to control the infestation in land where it is already present. These precautions have been successful and there is little doubt that they have also reduced the ill effects of other plant diseases and insect pests of the beet crop.

Virus yellows, which is spread by aphids, has caused extremely serious losses in sugar-beet crops, particularly in the years prior to 1951. During the period 1946–50 an average of 20% of plants had yellows at the end of August; in 1951–55 the corresponding figure was 11%; and in 1956 the crop was the healthiest on record with only 5% of infected plants. This improvement in the position has largely been the result of the combined efforts of scientists, field staffs and others, although it is difficult to assess how much is due to changes in cultural practices and climatic conditions. The methods adopted for controlling the disease have been to reduce the sources of infection from which the virus spreads to the young root crop in spring. Strict control measures have been instituted with regard to sugar-beet seed production and the introduction of systemic insecticides has also helped to reduce the level of infection. Another method of combating the disease is to breed strains of sugar-beet that are resistant or tolerant to its effects and, although work on these lines has been continuing for a number of years, it appears likely that it will be some time before resistant varieties are available. Despite the reduction in the incidence of virus yellows in recent years, there is no room for complacency and great vigilance is required to keep the disease in check. The fact that in 1953 it was estimated to have halved the yield in northern France is a constant reminder of the possible danger to the crop in this country.

Mechanisation

One of the greatest achievements of the sugar-beet industry in recent years has been the rapid progress made in the mechanisation of the crop. Particularly does this apply to harvesting machinery. The percentage of the crop harvested by machines has increased from approximately 1% in 1946 to nearly 50% in 1956. This advance in mechanisation has largely been the result of necessity. Rising costs and the ever-increasing shortage of farm labour have caused grave difficulties to the sugar-beet grower, especially in those parts of the country where industry has attracted large numbers of young men from the farms. This is shown by the wide variation in the degree of mechanical harvesting in



Close-up view of the original Great Western down-the-row thinner fitted with eight-tined heads for thinning four rows at once

Sucro-crystallography

SUCROSE shares with common salt the unique distinction of being both a food and a crystalline chemical. Both are consumed in enormous quantities, and according to Mr. H. E. C. Powers, Chief Chemist of the Thames refinery of Messrs. Tate & Lyle, the world uses some 40 million tons of sucrose per annum. Addressing the Food Group of the Society of Chemical Industry recently, he expressed the view that whether he is concerned with the production or with the utilisation of sugar, the technologist needed to have some knowledge of crystal characteristics, because the physical condition of the sucrose affects its utilisation. Spray-dried sucrose is quite a different product from crystalline sucrose; small crystals below 1μ in size are more easily soluble than large crystals; dendritic, irregular or conglomerate crystals are difficult to clear of syrup, and in some cases the syrup is occluded within the crystal.

The ruthless one

IN the fight against the locusts in the Sudan the Sudanese locust control has used up 7,750 tons of poisoned bait and employed an extra 350 vehicles in work which may influence the effect of locusts on East Africa later this year.

The Director of the Desert Locust Survey has said that this was international work of direct benefit also to East Africa and may settle whether or not East Africa got locust swarms towards the end of this year.

According to Dr. R. C. Rainey, of the Desert Locust Survey, the basic problem of locust control is one of dealing, at source or subsequently, with large, mobile insect populations, at times of the order of 100,000 tons of locusts, travelling distances often of the order of 1,000 miles in a few weeks, and each with a daily food consumption of the order of its own weight of plant material. For effective control the main operational effort has accordingly to be made hundreds of miles outside the crop areas to be protected, under conditions often severely restricting the choice of control materials and methods.

The desert locust, unlike other important swarming species, has no restricted, permanent outbreak areas lending themselves to continuous supervision and control (ecological or chemical) by a small, static organisation; and swarms are always to be found somewhere within the 11 million square miles subject to invasion, of which a total of at least 400,000 square miles experiences breeding by swarms during 50% or more of years.

The Locust Control Committee for Eastern Africa has just set up a permanent secretariat in Addis Ababa with funds provided by FAO. It will co-ordinate and assist locust work throughout Eastern Africa—the Sudan, Ethiopia, Somaliland Protectorate, French Somaliland, Somalia and Kenya.

Paper from sugar-cane

FOR every ton of sugar extracted from the cane a ton of fibrous residue, known as 'bagasse', is left. It is generally treated as a waste product and burnt in the boilers for raising the steam needed for processing the sugar.

Now, according to the U.S. Department of Agriculture, it could be used as a raw material for the production of pulp for paper-making and could also help to relieve the shortage of newsprint, as the potential world supply is immense and is estimated to be 25 million tons per annum.

A process has been developed by the Agricultural Research Service at the Northern Utilisation Branch Peoria, Ill., whereby the fibres are separated from the pith; the pulp so obtained is suitable for the production of fine bleached papers, stationery and packaging materials, as it is stronger in all but resistance to tearing than the softwood pulps produced by the acid sulphite process. It is claimed, too, that this 'mechano-chemical' process gives higher yields of high-grade pulp at lower cost. Bagasse pulps are especially suitable, it is said, for blending with other wood pulps for making a wide variety of paper products.

The absorbent pith, too, is finding a use as a carrier for molasses to produce a solid, easily transportable high-energy feed for cattle. The potential market for waste black molasses, which is relished by cattle, is estimated to be nearly a billion* gallons a year.

In Louisiana and Florida, where 900,000 tons of bagasse are produced annually, a considerable amount goes into making wallboard; some is also processed into poultry litter, and there are considerable possibilities, as some 14 million tons of all types of litter are used annually in the U.S.A. A paper mill in Louisiana is already producing between 20,000 and 25,000 tons of newsprint annually from bagasse.

Cattle in India

THE number of cattle in India is reckoned to approach a total of 200 millions, a figure which may be correlated with a population of 400 million souls and a gross sown area of 330 million acres, of which 85% is planted to food crops.

The average yield of milk per cow in India is said to be 410 lb.—the lowest in the world—compared with averages ranging from 2,000 to 7,000 lb. in other countries. Only about one-sixth of the cattle yield any milk and one-fifth are useless for any purpose, except for producing dung, which is collected, caked and dried for use as a fuel.

The consumption of milk and milk products in India is below half the desirable level, even though milk is the main source of animal protein for most Hindus.

One of the early shocks an agriculturist has on visiting India is the general low standard of the cattle.

*1 billion = 1,000 millions.

Herds roam, apparently at will, over the sparse pastures, scavenge in the bazaars, and interbreed at random. Grazing is usually of short duration, for when the monsoon arrives all possible land is ploughed and planted.

Cattle in India can do well, as the military farms in the Punjab bear witness and the agricultural stations have repeatedly demonstrated. When an Indian cow is crossed with an Ayrshire, for instance, the milk yield is increased tenfold or more, but bulls from such crossings have small humps, which characteristic reduces their value as draught animals. Nevertheless, other crosses with humped types produce suitable draught animals and good milkers.

But the cow is sacred in India and any interference with it is resented by the majority. It may not be killed, its meat may not be eaten and strict Hindus even refuse to touch leather made from cowhide. Yet the poor beast is usually short of feed and when used as a draught animal may be treated in a most brutal manner. Meanwhile, the herd increases and deteriorates, more grazing land is constantly sought, more Indians go undernourished and more food has to be imported. *The whole set-up regarding cattle in India is impossible to reconcile with conditions in the world of today.*

As previously reported in WORLD CROPS (1957, **9**, 52), there was a startling rise in milk production in Russia when the number of milk cows was reduced to adjust the cow numbers to the fodder available. To the Western mind, it is incomprehensible that this cannot also be done in India; the nearest approach has been a suggestion that surplus animals could be bought up and driven into the desert—an idea which fills us with horror.

There is no doubt that disaster lies ahead if nothing is done. Through over-grazing the pastures never get a chance to recover and the fertility of the soil will deteriorate until extreme desert conditions are established owing to the total destruction of all ground vegetation and the total disappearance of organic matter in the soil. A research possibility which merits consideration is the use of controlled atomic radiation or some form of veterinary treatment to reduce or control the rate of reproduction of these pathetic animals. It would, however, be necessary to compensate the owners, as the cow is almost the sole possession of the villager.

Salt and soil

IT is quite possible to overlook the important relation between the mineral constitution of a soil and its physical structure. Only when the mineral balance has been so seriously upset that the soil structure is in danger of breaking down does it appear imperative to apply minerals for the specific purpose of restoring good soil texture.

Such a situation has arisen in large areas of Essex, where, in the winter of 1953, 41,000 acres of farmland were inundated by the sea. On some parts the sea water remained for several weeks and left behind from 20 to 30 tons of salt per acre. The effect of this salt was to displace the calcium contained in the soil by sodium and the cure was to reverse this substitution.

The application of two tons per acre of calcium sulphate, combined with good drainage, has given promising results. Alternatively, the land was left fallow or drained, but in either case recovery was slow and premature attempts to crop previously flooded and untreated land have led to poor results; it will be many years before this soil will be restored to its former condition.

Diagnosis by subtraction

INCREASING attention is being given to the use of fertilisers in tropical agriculture. Following former European practice, attention has for far too long been focused on nitrogen, phosphorus and potash, singly or in combination. Only in recent years have the remaining nine or 10 elements known to be essential for plant growth begun to receive attention.

This preoccupation with NPK has tended to restrict thought and experimentation, and the result of the applications of these ' major ' elements at various levels and in various combinations, under various conditions, have sometimes been conflicting and inconclusive. Responsible planters, too, have complained that the response to the application of such fertilisers has been disappointing in that, after a period during which responses are spectacular, yields begin to fall off.

The evidence of the widespread incidence of ' minor ' element deficiencies, taken in conjunction with the indications of the magnitude of their possible effect on crop yields, serves to emphasise that the approach to the problem of fertiliser trials, at least in the tropics, needs broadening, according to R. A. Webb, of the A.R.C. Unit of Plant Nutrition, Long Ashton, in his address to the Agriculture Group of the Society of Chemical Industry in the course of the symposium on ' Trace Elements in Soils, Plants and Animals '.

Experiments have shown that major element responses can be limited drastically by trace element deficiencies and vice versa, and it is possible that the lack of response to the application of a particular element can be due to another simultaneous deficiency in the soil. One is faced, therefore, with the necessity of testing a large number of mixtures of increasing complexity, but for diagnostic purposes such a procedure would be too unwieldy.

He concluded that if a reasonably balanced *complete* fertiliser, containing all the known essential elements, were used as a standard, comparisons might be possible between the response to the complete fertiliser and responses to deficient mixtures prepared by omitting each element in turn from the complete mixture. He called this the ' subtractive ' method.

Multum in parvo

A REPORT of the proceedings of this conference will appear in the July issue of WORLD CROPS. The discussions reached a very high level and showed that workers in this difficult field of research have gone a long way towards determining the role of trace elements in the nutrition of plants and animals. The farmer, the planter and agriculturists are primarily concerned with the application of the results of these researches in agriculture.

A film, which was shown to the members attending the conference, showed how important fundamental research in this field is likely to be for the future welfare of mankind. Even though some of these minor elements are only required to the extent of a few ounces per acre, this trace can make all the difference between success and failure in the production of agricultural crops.

The film—' The Pumice Lands '—showed how the useless and infertile fern and tussock country of the central plateau of North Island, New Zealand, has been converted into green pastures. The soil was of the right physical texture, but was short of two essential nutrients—phosphorus and cobalt—the latter being required to the extent of only 2 or 3 oz. per acre.

The rehabilitation of these ' badlands ' was organised as a combined operation by the Government. First, 200 miles of roads had to be made and electric power brought to the area; then the coarse brushwood and vegetation was smashed down with heavy, spirally-fluted rollers; the debris was burned and any irregularities in the land were smoothed out with bull-dozers. After ploughing and harrowing, the two fertilisers and pasture seed were applied from the air and the settlement of the area was begun.

In the March issue of WORLD CROPS there was an account of a similar operation in the 90-mile desert of South Australia, where life was given to the land by the use of zinc and copper, also applied in trace amounts, as a result of which land values increased from A£1 to A£25 per acre. Elsewhere the application of phosphorus and molybdenum and the introduction of subterranean clover into the pastures have resulted in twofold to threefold increases in productivity.

Trace element deficiencies are also becoming increasingly evident in the U.S.A., where over 35 areas are reported to be deficient in molybdenum. This element plays a part in the reduction of nitrates to nitrites and in plants suffering from molybdenum deficiency it has been found that the concentration of nitrates becomes unusually high. Work done by D. Spencer and J. G. Wood in Australia has shown that when molybdenum is applied to molybdenum-deficient tomato plants there was a marked increase in the level of nitrite and ammonia and later in the level of amino acids and proteins, with an accompanying decrease in the nitrate level.

The status of molybdenum in agriculture and the possibility of reclaiming land in the Hawaiian Islands has been reported by G. S. Cripps. Webb, too, in the paper which he presented at Bristol gave an account of deficiencies of boron, copper, manganese, molybdenum, zinc and iron which had been found in major crops in various tropical countries.

Farms or forest

ONE of the best reports upon land use in Britain has come from the Natural Resources (Technical) Committee—' Forestry, Agriculture, and Marginal Land '.* Can a country so thinly endowed with natural resources as Britain afford to neglect so much of its land, even though it may be classified as marginal, be remote from modern services, sited on hills, or of low fertility? Need all the land now arbitrarily classified as marginal remain marginal?

The Committee's principal suggestion is to put back the trees on our hills. Afforestation as well as agriculture is urged, with a bias towards trees for remotely-sited hill land and for more steeply-sloped hill land, whether remote or not. As the neglect of forestry in Britain is greater even than the neglect of farming of marginal land, there is much to be said for this dual policy, despite past evidence of incompatible rivalry between agriculture and forestry.

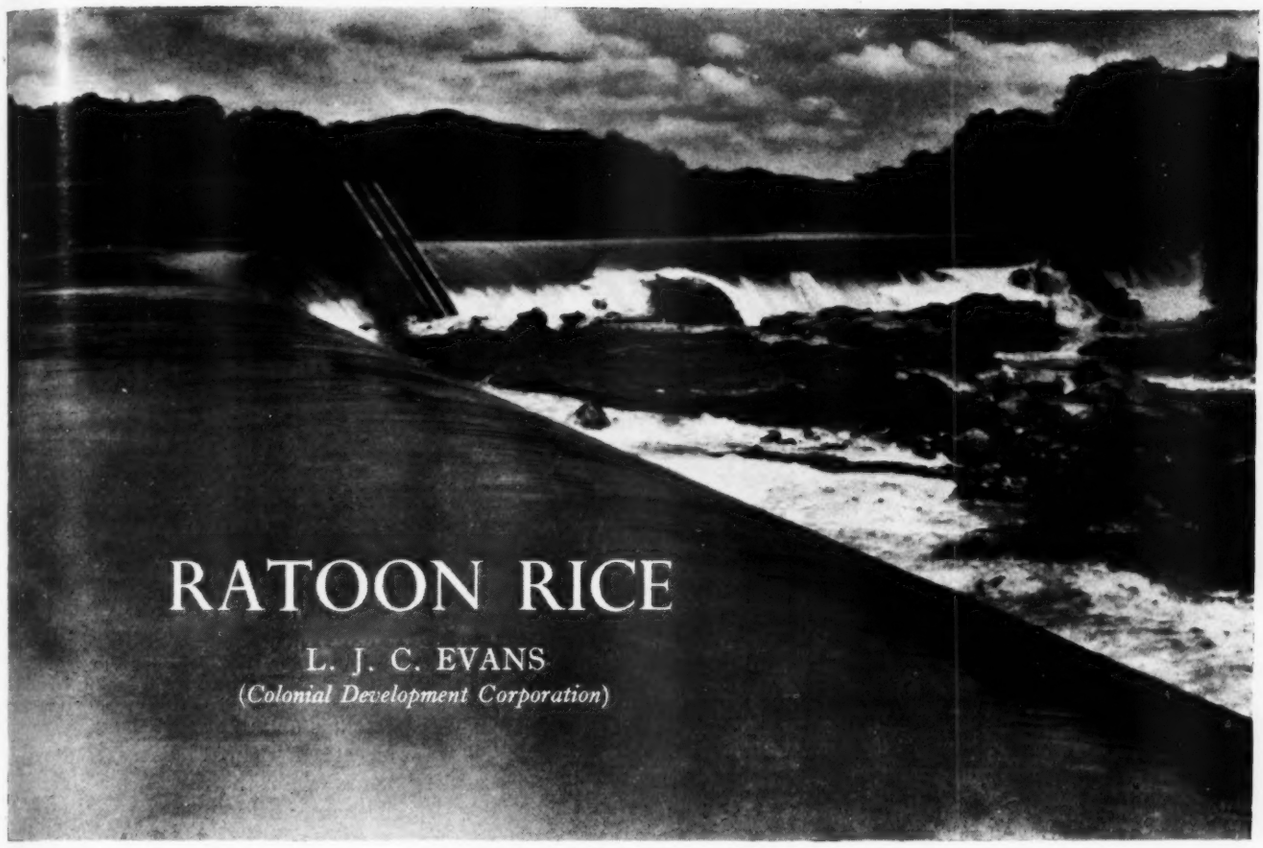
Upland grazing integrated with small plantations of pine or spruce would produce winter shelter for stock and forestry work could provide a partial occupation for agricultural workers during slack periods.

Whether marginal upland farming is to be given further encouragement or not, a bold policy of afforestation is obviously desirable. Climate and soils in Britain are said to be more favourable to tree growth than in the leading timber-producing countries of Europe. In Britain the rate of growth attainable is more than twice that in Sweden for pine, and nearly twice the Swedish rate for spruce.

However, less than 7% of our land space is under trees, whereas the corresponding figure in West Germany is 28%; in Denmark, 10.4%; in Norway, 24%; and in Sweden, 56%. The long-term nature of investment in trees and competition between forestry and agriculture for marginal land have both contributed to the neglect of a crop so naturally suited to our conditions.

The Committee's enquiries have shown that annual return from capital investment in afforestation is slightly better than the return from investment in marginal land farming, if new farm buildings are required for the latter. Perhaps even more vital, the import savings to be expected from afforestation are substantially greater than import savings through the farming of marginal lands on the hills. It can also be argued that the world today is even shorter of timber than it is of food.

* H.M.S.O. 4s.



RATOON RICE

L. J. C. EVANS
(Colonial Development Corporation)

Diversion weir in the Komati River

Various aspects of the Swaziland Irrigation Scheme have been discussed in a previous issue (WORLD CROPS, 1956, **8**, 67). *A ratoon crop of rice may be grown either in the same year as the main crop or in the year following. In this article the two systems are compared.*

THE first stage of the gravity canal scheme, begun in 1955, is due to be completed in 1957. The diversion weir in the Komati River was actually completed before the end of 1956. Pending completion of the gravity irrigation system, irrigation water for rice growing has been provided by pumping from the Komati River on to some 2,000 acres of land which have been laid out on the north-east corner of the scheme. This followed a 200-acre pilot scheme which was laid out in 1951–52 based on experience gained in experimental trials.

Previous system of ratooning

The system of taking ratoon crops of rice previously described (see introduction) involved planting the main crop during the spring or early summer months (September–October). After harvesting the main crop some four months later, the stubbles were flooded and a second crop was allowed to grow, and this was harvested about three months after the first crop. The growing period of the ratoon crop was shorter than that of the main crop, because its root system was already established. In this way two crops of rice were harvested in the same year.

Several difficulties in this particular system of ratooning have come to light. One of the difficulties is in the control of weeds. Unless the main crop can be harvested early—say January–February—the subsequent 'autumn ratoon' crop does not make satisfactory growth. For the main crop to be harvested early, it is necessary to plant it early, but planting as early as August–September does not allow sufficient time for the pre-sowing cultivations which are essential for weed control. These pre-sowing cultivations do not effectively control weeds if they are done prematurely. Until the seasonal rise in temperature is sufficient to induce germination and growth of weeds such preparatory cultivations can be a waste of time. Fields kept tilled through the winter months may look clean, but nevertheless may carry a heavy weed growth when summer comes.

Carrying out the pre-sowing cultivations at the right time means delaying the planting of the main rice crop for about a month. Planting can start in October–November, but this means that the majority of the crop is harvested too late for the subsequent autumn ratoon to make satisfactory growth. It may be possible to take autumn ratoons from those fields which are the first to be planted with main crop paddy, but autumn ratooning cannot be regarded as a satisfactory system for the majority of the planted area.

The new system

It has been found during the past two years that a much more satisfactory system of ratooning is not to follow the main crop immediately with a ratoon crop, but to allow an interval of about six months between harvesting of the main crop in January–February–

Work in progress on one of the siphons during construction of the main canal in the Swaziland Irrigation Scheme

March and the cultivation of a ratoon in the following spring. Under this system the main crop is planted in October–November after the fields have been flooded to promote weed growth, which is then disk-harrowed or ploughed under before the paddy is sown. The main crop is harvested in January–February–March, after which the fields are allowed to remain in stubble, without any irrigation, until the following spring.

When the spring rise in temperature occurs about August–September the stubbles are irrigated and the ' spring ratoon ' crop begins to grow, and is ready for harvesting about January.

Advantages and disadvantages

Under this system only two crops of rice are obtained in two years, a main planted crop in the first year and an unplanted spring ratoon in the second. The cost of the ratoon crop is appreciably less than that of the main crop because the ratoon does not have to bear the costs of land preparation and planting, and the ratoon crop needs about 20% less irrigation water than the planted crop. Yields of the main crop under good conditions are about 2,700–3,000 lb. paddy per acre; that of a good spring ratoon crop is about 2,300–2,400 lb. paddy per acre.

There are other advantages of ratoon crops besides lower production cost and lower requirement of water. If a proportion of the rice produced each year is derived from ratoon crops, less machinery, equipment and labour are required for land preparation and planting because these operations are not, of course, required in the case of a ratoon crop. Also on experience to date the spring ratoon crop seems to be relatively free from weeds and from self-sown rice.

There could, however, be some disadvantages associated with rice ratooning. The most obvious is that the taking of ratoon crops and leaving all stubble in the ground unploughed may allow a build-up of pest populations. There has been some indication that ratoon crops may be fairly heavily infested with rice stem borers, including *Ampycodes pallidicosta*, though so far the loss of crop, either in the main crop or the ratoon, does not appear to be considerable.

Pests

In addition to rice stem borers of several kinds, there has been loss of crop due to attacks by rice leaf beetle, *Trichispa sericea*. Serious damage was done to the 1954–55 rice crop by rice leaf beetles before the pest was brought under control by spraying with dieldrin.

Weeds

In common with most areas where rice is planted, rather than transplanted, weeds become a serious problem if rice is planted year after year in the same field without rotation. Rotation trials in Swaziland are under way, including trials not only of alternate winter and summer crops, but also of grazing by cattle. In addition to a considerable area of irrigable land, the Swaziland Irrigation Scheme has upwards of 60,000 acres of dry land suitable for ranching. The scheme at present maintains 8,000 head of cattle and plans to increase the numbers progressively. It is expected that integration of livestock and crops will then develop.

The worst weeds of the rice lands are, as is commonly the case, grasses, including *Echinochloa* species. Accurate levelling and water control are essential and so also is control of weed growth in drainage lines and reserve lands within the rice area. Herbicide trials are now in progress.

Varieties

When rice growing began on the Swaziland Irrigation Scheme a variety found in Natal, known as UVS, gave promising results. This was grown on a fairly large scale until it began to be replaced by the variety ' Blue Bonnet ', seed of which was imported from the U.S.A. in 1954. ' Blue Bonnet ' is now providing satisfactory crops both from main crop and ratoons and the quality is popular locally.

Using a self-propelled combine-harvester for harvesting ric

SUGAR-BEET GROWING IN THE U.K.

D. C. G. THOMSON, B.SC.

(*Agricultural Development Department, British Sugar Corporation Ltd.*)

Sugar-beet is today one of the leading cash crops in Great Britain. An area of over 400,000 *acres produces an annual tonnage of between* $4\frac{1}{2}$ *and* $5\frac{1}{2}$ *million tons of beet, which is processed into the equivalent of between* 600,000 *and* 700,000 *tons of refined white sugar. In addition, approximately* 300,000 *tons of dried molassed sugar-beet pulp are produced and this, together with vast quantities of tops and crowns, are used as food for cattle.*

Two crops in one. Sugar is extracted from the root and the residual pulp and the tops and crowns are used as cattle feed

ALTHOUGH sugar-beet cultivation became firmly established in Great Britain only about 30 years ago, great progress has been made in the many aspects concerned with the production of this relatively new crop. Apart from the important addition to the national income, sugar-beet cultivation also helps to improve the soil, and the beneficial effects on succeeding crops obtained from the more intensive husbandry required by the beet crop—particularly deep ploughing and heavy manuring—has resulted in a great improvement in the general standard of farming. The by-products available encourage the grower to maintain stock on the farm, which again results in higher fertility of the land.

Research and education

In the early days advice to the grower was based largely on European practice, which was only to be expected considering that sugar-beet had been grown on the Continent for many years before its introduction to this country. In the following period, however, and particularly after the amalgamation in 1936 of all the existing 18 sugar factories to form the British Sugar Corporation, an extensive and expanding programme of research and education was carried out until, at the present time, over £70,000 has been earmarked for this purpose. The programme is administered by the Sugar Beet Research and Education Committee, which comprises representatives of the Agricultural Research Council, the Agricultural Improvement Council, the British Sugar Corporation and the National Farmers' Unions. The chairman of the committee is appointed by the Government and when required for dealing with technical questions representatives from the following research and other centres are also present: British Sugar Beet Seed Producers' Association, National Institute of Agricultural Botany, National Institute of Agricultural Engineering, Norfolk Agricultural Station, Plant Breeding Institute, Cambridge, Rothamsted Experimental Station, School of Agriculture, Cambridge, and the Scottish Society for Research in Plant Breeding.

Much of the field work is carried out by the agricultural staff of the British Sugar Corporation at the sugar factories, so that many of the experiments (*e.g.* variety trials) are conducted under the widest possible range of soil and climatic conditions in the areas where commercial beet crops are grown. The British Sugar Corporation also plays a prominent part in the educational side of the Research Committee's activities, the scope of which may be judged from the above list of research centres engaged on the many aspects of the work involved.

Increased yields

A measure of the tremendous progress made in sugar-beet growing during the past few years can be gauged from the striking increase in the yields obtained. The seven-year average yield (1950–56) is over $11\frac{3}{4}$ tons per acre, which compares with the average during the previous seven years of only $9\frac{1}{2}$ tons per acre. The highest yield yet recorded was 13.1 tons per acre in 1953, the second highest (12.8 tons per acre) in 1950, and the third highest (12.6 tons per acre) was achieved last year. Apart from the effect of favourable climatic conditions, which it is practically impossible to assess accurately, these extraordinary increases in yield are without doubt the result of a combination of many factors, the more important of which may be summarised as follows: earlier sowing, improved varieties, more effective pest and disease control, higher plant populations and the use of heavier dressings of artificial fertilisers. Other advances made in recent years have also contributed to the higher standard achieved: for instance, seed treated with combined fungicide and anti-wireworm dressings and spraying for chemical weed control. Improvements in cultural practices and the accumulated knowledge and experience gained in growing the crop must also have a considerable influence. Examples of the latter are illustrated by the fact that at one time severe damage due to wireworm and crop failures, due to soil acidity, were fairly common, but losses from these causes are now comparatively rare.

For many years early sowing has been advocated as a means of increasing yields, as it was known that the sugar-

A modern four-unit precision drill (Stanhay) in use in Lincolnshire

beet plant requires a fairly long growing period to reach maturity under normal conditions in this country. The highest yields have nearly always been obtained in years when the crop was sown early—in the record years of 1950 and 1953 nearly 40% of the crop was sown in March, and this has confirmed the results of previous trials. Nowadays drilling of sugar-beet normally commences about the middle of March and under normal conditions most of the crop is sown by the middle of April.

Bolting

Sometimes progress in one direction causes additional problems and this applies in the case of early sowing, which tends to increase the percentage of ' bolters ' in the crop. Sugar-beet is a biennial plant, but under some conditions it produces flowering stems in the first year. This so-called ' bolting ' is undesirable because the roots of bolted beet are usually smaller, lower in sugar content and extremely tough, thus causing difficulties at harvest time, particularly when mechanical harvesters are used. The tendency to bolt is a varietal character and considerable progress has been made by plant breeders in recent years in producing varieties that are comparatively resistant to bolting. However, this is still a serious problem and the advantages of early sowing are so great that constant efforts must be maintained and, if possible, increased in order to reduce the bolting tendency.

Seed breeding

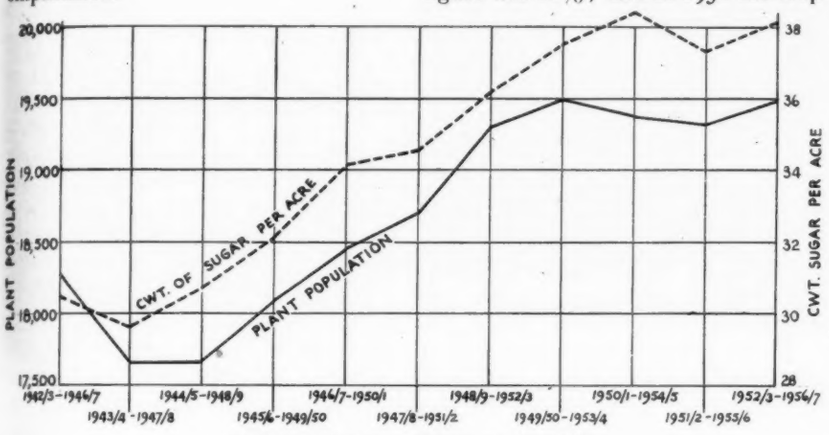
Before the last war most of the sugar-beet seed used in Great Britain was imported from the Continent, but as these supplies were eventually cut off, seed had to be produced in this country and the position is now completely reversed. Previously a larger proportion of ' N ' and ' Z ' varieties (which produce a higher sugar content and medium weight of root) was used, but now the ' E ' types, which tend to give higher yields and slightly lower sugar contents, are more popular. This again may account to some extent for the higher tonnages obtained in recent years. A development in seed breeding during the last few years has been the introduction of polyploid sugar-beet seed. Sugar-beet is normally a diploid plant, but by the application of new techniques triploid and tetraploid plants are produced which have given favourable results in some European countries where polyploid varieties are now widely used. In this country the breeding of polyploids is in its early stages and it is expected that good results will be obtained in due course.

Plant population

The effect of plant population on yield has been studied in numerous experiments carried out for many years and these have invariably proved the benefits of high plant numbers per acre. Although increases in yield obtained by raising the plant population varies according to climatic, soil and other conditions, there is no doubt that a high plant population is the best safeguard against poor yields, particularly in dry years or when pests and diseases are more prevalent. The graph shown opposite, reproduced from the *British Sugar Beet Review*, which records the progressive five-year averages for plant population and yield of sugar per acre, illustrates the close correlation between the two. The populations shown are the calculated number of plants delivered to factories and consequently are slightly lower than the plant numbers obtained in the field.

The general recommendation is to aim to leave 30,000 plants per acre, although this number is not often achieved in practice. The first essential for obtaining a satisfactory plant population is the production of a good even braird of seedlings without gaps, and this is probably the most critical stage in sugar-beet cultivation. Satisfactory emergence of beet seedlings is dependent on a number of factors, the most important being a fine, firm seed bed with an adequate moisture content. Methods of seed-bed preparation vary in different parts of the country, but generally there is a tendency towards less deep cultivations which help to conserve soil moisture and

produce a finer surface tilth. One-way ploughs, land levellers, wooden-framed harrows, tractor wheel extensions and other implements which assist in producing a level surface are becoming more widely used, and with the increase in subsequent mechanical operations on the crop the importance of obtaining a level surface cannot be overemphasised.



Plant population and increase in yield

Pests and diseases

Losses due to pests and diseases in countries where beet growing had been established for many years caused the factories in this country to begin research work quite early in the life of the industry. Sugar-beet is no exception to other crops in being subject to a fairly wide range of pests and diseases and the most important of these are beet eelworm and virus yellows. Beet eelworm was first found attacking sugar-beet in Great Britain in 1934 in the eastern counties, although it had been discovered on mangolds in 1928. In order to prevent the spread of this malady, often called ' beet sickness ', which has had disastrous effects in other countries, the British Sugar Corporation, in agreement with growers, included a clause in the sugar-beet contract under which the successive planting of sugar-beet and related crops on the same land is controlled. When it became clear that more drastic measures were required, the Minister of Agriculture and Fisheries made the Sugar Beet Eelworm Order of 1943. This Order was revised in 1952 and is designed to prevent the spread of eelworm and to control the infestation in land where it is already present. These precautions have been successful and there is little doubt that they have also reduced the ill effects of other plant diseases and insect pests of the beet crop.

Virus yellows, which is spread by aphids, has caused extremely serious losses in sugar-beet crops, particularly in the years prior to 1951. During the period 1946–50 an average of 20% of plants had yellows at the end of August; in 1951–55 the corresponding figure was 11%; and in 1956 the crop was the healthiest on record with only 5% of infected plants. This improvement in the position has largely been the result of the combined efforts of scientists, field staffs and others, although it is difficult to assess how much is due to changes in cultural practices and climatic conditions. The methods adopted for controlling the disease have been to reduce the sources of infection from which the virus spreads to the young root crop in spring. Strict control measures have been instituted with regard to sugar-beet seed production and the introduction of systemic insecticides has also helped to reduce the level of infection. Another method of combating the disease is to breed strains of sugar-beet that are resistant or tolerant to its effects and, although work on these lines has been continuing for a number of years, it appears likely that it will be some time before resistant varieties are available. Despite the reduction in the incidence of virus yellows in recent years, there is no room for complacency and great vigilance is required to keep the disease in check. The fact that in 1953 it was estimated to have halved the yield in northern France is a constant reminder of the possible danger to the crop in this country.

Mechanisation

One of the greatest achievements of the sugar-beet industry in recent years has been the rapid progress made in the mechanisation of the crop. Particularly does this apply to harvesting machinery. The percentage of the crop harvested by machines has increased from approximately 1% in 1946 to nearly 50% in 1956. This advance in mechanisation has largely been the result of necessity. Rising costs and the ever-increasing shortage of farm labour have caused grave difficulties to the sugar-beet grower, especially in those parts of the country where industry has attracted large numbers of young men from the farms. This is shown by the wide variation in the degree of mechanical harvesting in

Close-up view of the original Great Western down-the-row thinner fitted with eight-tined heads for thinning four rows at once

Sugar-beet harvesting in Suffolk, using a complete mechanical harvester (Catchpole) which tops, lifts and cleans the beet and delivers them into the trailer alongside

different areas, which ranged in 1956 from 20% up to 75%. Great credit is due to the manufacturers of the harvesters and the operators in surmounting the many problems involved, but it would be unwise to conclude that the ultimate goal has been reached. Further improvements are still necessary in the standard of work achieved, and particularly in the operation of machines on heavy or stony land, and under wet conditions. For the past 11 years the Sugar Beet Research and Education Committee has sponsored an annual national demonstration of sugar-beet harvesting, which since 1950 has included tests on the performance and efficiency of the machines entered. There is little doubt that the effect of these demonstrations and the publication of the results obtained has not only been to increase sales, but also greatly to improve the design and performance of the harvesters. The present tendency is towards smaller and lighter machines which carry out the complete process of lifting, topping and cleaning in one operation.

An additional difficulty now facing harvester manufacturers is to design an efficient topping mechanism to deal with irregularly spaced crops resulting from the use of down-the-row thinning machines, which are likely to increase in numbers during the next few years. Although harvesters have gone a long way towards overcoming the autumn labour peak, the relatively large amount of hand labour required for singling the crop in the spring is now an even more important problem which has been tackled by intensive experimental and development work in recent years. This has involved various lines of research, including the introduction of precision-type drills with the object of placing each seed unit separately in the ground at predetermined intervals, the evolving of sound methods of operating down-the-row thinning machines, improved cultural practices in order to produce better and more level seed beds, the use of chemical weed control sprays and efforts to improve the quality of various types of sugar-beet seed by processing, grading and other methods. With regard to the latter, the ultimate object is the production of genetical single-germ seed with high germination and vigour. Great progress has already been made in mechanisation of spring operations—nearly 7% of the crop was sown with precision drills in 1956.

There is no doubt that, in the past 10 years, research work has played a most important part in assisting sugar-beet growers and farmers to overcome the difficulties created by shortage of labour and rising costs. The march of progress has added to the complications of modern farming, but the basic purpose remains the same—to maintain and, if possible, increase the fertility of the soil by following the established principles of good husbandry.

Photos, other than p. 229, by courtesy of the British Sugar Corporation Ltd.

Coming Events

Applied Entomology.—A two-week course, from 23 June to 6 July, has been arranged by the British Council, in co-operation with Rothamsted Experimental Station, for entomologists and agriculturists who wish to obtain up-to-date experience of the practical use and the methods of study of insecticides.

Agricultural Fair.—A National Agricultural Exhibition will be held at Utrecht from 24–29 June. The exhibition will be devoted to agriculture in the widest sense, giving evidence of the significance of the agricultural industry in Dutch economy.

Royal Show.—The British Royal Show is to be held this year at Norwich from 2–5 July.

Rural Extension.—The annual International Meeting on Methods and Programme Planning in Rural Extension will be held from 2–31 July at Wageningen, the Netherlands.

Chemical Industry.—The 76th annual conference of the Society of Chemical Industry of Great Britain takes place at Leeds from 8–13 July.

Crop Protection.—The 4th International Congress of Crop Protection will be held in Hamburg, Germany, from 8–15 September. Further details may be obtained from the Biologische Bundensanstalt für Land- und Forstwirtschaft, Messeweg 11/12 Braunschweig.

Fertilisers. — The 3rd Fertiliser World Congress will be held from 9–12 September in Heidelberg, Germany. The Congress will consider: (1) modern fertilisation, soil fertility and working results. (2) the importance of mineral substances for plant life. (3) modern fertilisation and merits of agricultural products.

General Science.—The 119th annual meeting of the British Association for the Advancement of Science will be held in Dublin, Eire, from 4–11 September. The programme this year is to have an agricultural slant and there will be an exhibition of equipment and methods at University College, Dublin. Further particulars may be obtained from the Secretary, British Association, Burlington House, Piccadilly, London, W.1.

[Organisers of forthcoming international agricultural events are invited to send particulars to the Editor.]

THE MECHANISATION OF RICE PRODUCTION

In 1954 FAO arranged for a working group to make a comparative study of rice growing in Asia and the Far East, with particular reference to mechanisation. This account of its findings, provided for us by FAO, shows the value of exchanging information on implements and methods and pooling resources of research as a preliminary to progress.

SINCE its foundation in 1949, the International Rice Commission has given consideration to the problems of mechanisation of rice production under wet paddy conditions. The 4th (1954) Session of the International Rice Commission asked FAO to set up an *ad hoc* technical working group 'to study and evaluate the whole subject of mechanised rice production techniques . . . in Asia and the Far East'. This group was intended to supplement the routine co-operation between FAO and member governments, chiefly concerned in rice growing, especially on such wide general problems as water-lifting and farm management practices. Seven governments—Burma, Ceylon, India, Japan, the Netherlands, Thailand and the U.K.—appointed representatives to the group which met in May 1956, at Peradeniya, Ceylon.

Scope of inquiry

Although the group was concerned only with mechanisation under wet paddy conditions, the term 'mechanisation' was considered in the broadest sense. It covered everything from the simplest hand tools through animal-powered equipment to motorised equipment of the most modern types. The field of study ranged from water-lifting devices to the effects of mechanisation in any form on farm management practices. Through farm management, it touched on the problems inherent in dealing with farms held, under various land tenure systems, as well as on the effects of the labour market on the use of equipment of various types. Throughout, FAO has emphasised that the agricultural engineer is above all a crop production engineer, and not merely a technician working on technical design problems, divorced from the considerations imposed by the whole field of agricultural development in the rice-growing countries of the Far East.

A new type of tractor for puddling and levelling irrigated paddy in Japan

From the first, an attempt was made to formulate clearly and concisely the problems to be considered, through defining (*a*) the primary objectives of any particular operation associated with rice production, and (*b*) the cultural requirements to be attained in reaching these objectives. The existing types of equipment, hand- and/or animal-powered or fully motorised, were then considered in relation to these main requirements. Dry land rice has few special requirements different from any other cereal crop, when it comes to the use of mechanical equipment, and the necessary techniques have been well worked out over a long period of years. Mechanisation of wet paddy production, on the other hand, poses a whole set of problems peculiar to itself, and it is only within the last few years that any research has been done in this field. It was for this reason that the decision to interpret the word 'mechanisation' in the widest possible sense was taken, and the work of the group was subdivided into several parts. One sector of the field, that concerned with water-lifting for irrigation purposes, had already been done under FAO's regular programme, and the results of this published and submitted to the International Rice Commission (FAO Agricultural Development Paper No. 60—'Water-lifting Devices for Irrigation'). This was therefore not considered in detail, except where it touched on certain aspects of farm management.

Survey of existing practice

The group concerned itself chiefly with two quite different aspects of the

A harrow, pulled by oxen, levelling an irrigated rice field in Egypt

problem; the first, the technical examination of the performance and construction of all types of available equipment for each of the operations in rice production; the second, certain points of farm management of prime importance where mechanisation is under consideration. So far as the first was concerned, several general conclusions soon became apparent. In the Far East, hand- and animal-powered equipment is obviously in the widest general use, and for much the same purposes. Yet not only are the various countries using completely different sets of equipment, but the efficacy of what is being used also varies enormously, as also do the effects of the types of equipment on yields and soil conditions.

A good example of this has been provided by the 'puddling' tool known as the 'settun', used in Burma (puddling is the second stage of culture, before rice is transplated into a field, designed to provide optimum conditions for the young plant after transplating). The settun is a rotating drum-type instrument, having a central drum of wood or metal, to which are attached wood or iron blades, 4–6 in. long and about 6 in. apart. The drum is mounted on a heavy wooden frame, with beams in front of and behind it which act also as a smoothing board. Such an instrument is taken two or three times over the field after ploughing to produce a satisfactory 'puddle'. Until 1956, this piece of equipment was almost unknown in other countries, as, for example, in Ceylon. It was described, however, to the working group member from that country; he was shown drawings and photographs, and had a prototype built. Now puddlers of this type are in operation in Ceylon.

This incident demonstrated a point, applicable to all types of mechanisation in the under-developed countries. It is often said that there is great resistance to new tools and equipment in many such countries and that overcoming this is a major problem. Often this is indeed the case; but where an item is quite obviously better, and not prohibitively more expensive than the animal or machine already in use, there is not normally much difficulty. In fact, it has become evident that at present, perhaps the greatest improvements in mechanisation can be brought about by picking out the best equipment already in use in the region and gradually bringing about its introduction into other countries where conditions are similar. The interchange of information which this and other FAO groups strive to bring about is thus seen to be doubly important.

The prospects of mechanisation

Mechanisation in the sense in which it is usually used in the West evidently will come slowly to the great rice-growing regions of the Far East. The advent of mounted tractor implements, as opposed to trailed types, has made tractor mechanisation far more feasible, especially where fields are small, which is the case over most of the area in which wet rice is grown.

At the same time, manufacturers in general have hitherto not been much concerned with developing equipment for this type of work, perhaps partly because of the existence of adequate home markets for their normal output. But now that home sales may be declining, more attention could be paid to the special design of powered equipment of all types for what will be, sooner or later, an important market. It is already known that tractors can work favourably under wet paddy conditions (except in more or less bottomless peat soils), and that there is no need to produce special types for such use; indeed, economic reasons alone indicate that they should be no more than slightly modified versions of regular mass-produced models. It is only on very large projects, with which we are not at the moment concerned, that highly specialised machines would be an economic proposition.

The basic requirements can be summed up fairly simply. They are: high ground clearance, direct mounting of tillage implements; weight distributed well over the driving wheels in rear-wheeled types; and careful attention to traction problems. In regard to the last point, full tracklayers are considered neither necessary nor even desirable, and although all reports on half-track adaptations have been favourable, in general pneumatic tyres seem the most desirable of all, especially considering their wide all-round use. The design of the tyres themselves, however, is important. To quote the FAO group's report: 'If shear action is the main means of traction, a narrow tyre of large diameter is desirable; where friction or flotation (as on light silt soils) provides most of the tractive effort, a larger cross-section with very deep tread appears to give the best results'. Cage wheel extensions are often used to improve the efficiency of rubber tyres. In general, medium-powered tractors are quite adequate for this work.

In so far as smaller 'walking' tractors are concerned, less information seems to be available, although they have been tried in a number of areas. They are, however, being developed in some countries, especially Japan,

from where indeed a good many of the most useful ideas and items of equipment for wet paddy culture have been, or are being, evolved.

Transplanting

In wet paddy culture, one of the greatest labour-consuming operations is transplanting, which not only costs a great deal in time and money, but has a considerable effect on yields if not done well and at the proper time. At the same time, the advantages of transplanting as against direct seeding are in most cases worth the extra cost. Unfortunately, no aspect of paddy production lends itself less to mechanisation than this, and no satisfactory mechanical transplanter has yet been evolved, although considerable work has been done on the problem. Perhaps the most significant fact here is that even in Italy, where mechanisation even of wet paddy is particularly well advanced, practically all transplanting still has to be done by hand. The most that has been achieved over any large area is the use of a ' transplanting tool ', a metal rod about 18 in. long with a wooden handle and a small forked end. Two to four plants are put in the forked end, the tool plunged into the mud and withdrawn, leaving the plants *in situ*. This tool needs care in its use, but can be quicker and is less laborious than straight hand planting.

A combine-harvester on trial in Ceylon

Harvesting

Harvesting has also so far provided largely insoluble problems when it comes to powered, or even animal-drawn equipment. Mowers, in fact, have been found simply not suitable; a light self-propelled reaper is said to be under development, however, and rear-mounted power take-off windrowers have been more or less successfully developed which can be used in small fields. In general, however, it is only in large fields that the more modern equipment can be used. Rice combines have now been fairly well developed, but in view of the difficult soil conditions, considerable skill in their manipulation is necessary and the points already mentioned as regards tractors have to be even more carefully observed. On the other hand, threshing has been mechanised for some time in many countries, either by the treading by tractors or with drum-type threshers.

A hand-operated threshing machine in Liberia. In the background are shelters where the newly-harvested rice is dried over slow fires before threshing; the threshed rice is fanned in the tray and the cleaned rice is then spread on the concrete for sun-drying

The human factor

Coming now to the farm management aspects of mechanisation, it is at once apparent that the existing land tenure systems, and normally low level of income and absence of available capital are controlling factors. The peasant working a small farm consisting of a number of fragmented holdings can have little use for powered equipment, even if he could afford it, which he cannot—often, in fact, he may be unable to afford even animal power. Moreover, where there is ample family labour, improvements in the immediate future will best be brought about by developing better hand tools, simple animal-powered equipment, and actual methods of work. Only when there are good employment opportunities off the farm, which could absorb some of the

labour force, will mechanisation in the more usual sense really be efficient.

The answers to the questions posed on the farm management side can only come after prolonged study actually in normally operating farms, and for this reason little real information is at present available. The few studies that have been made have been almost entirely carried out at Government research stations or on single holdings, and are not representative.

In general, results seem to show that where mechanisation can be afforded, it is welcome. In Japan, for example, many young farmers are found who prefer to work with machines rather than with animals, even though, according to one local authority, there is already over-mechanisation in some areas. This is dangerous, since it may lead to indebtedness with a consequent lowering of living standards.

Puddling and levelling

One example of a detailed comparative study concerned the use of bullocks and a tractor for puddling and levelling. A total of 47 bullocks was used, and a group of five tractors and implements in the 25–35 h.p. category. The area considered was about 600 acres, and similar work was done by each group; the initial investment was approximately the same in each case. Analysis of the results showed that up to 500 work-hours per year, bullocks were slightly cheaper; beyond that they were gradually overhauled by the tractor, and at 1,000 hours the tractor was ahead by the same amount that bullocks had been at 500 hours. On the other hand, only one man was needed for full-time work with the tractor, as against four men with nine bullocks. Some form of co-operative farming, and/or increase in the size of farms, would be needed to provide sufficient work to make tractors more economical than bullocks.

Threshing

Other comparisons were made with threshing. For example, eight men using buffaloes threshed an acre's yield in six hours, whereas 20 men would be needed to trample out the grain in the same time. On the other hand, to make the use of the buffaloes economical on a year-round basis, a unit sufficiently large for 12 buffaloes would be needed. In the same way, the use of a tractor for 'tread threshing' was also much quicker (one tractor did in one day what would have taken six buffaloes 10 to 12 days) and cost half as much where buffaloes had to be hired. But it would be necessary again to find economical employment for the tractor for the rest of the year, though for threshing itself there might be great advantage in a quick method where this operation had to be done quickly for one reason or another.

These examples show the extreme complication of farm management studies in this field, and indicate that it will be many years before the answers are available. Land tenure problems, which lie at the base of much of this, are notoriously difficult of solution, and in the countries where the need is greatest there are also many other fundamental difficulties to be overcome, as, for example, on the statistical side, before real results can be obtained and decisions made. In fact, on both the technical and farm management sides, the FAO group concluded that basic studies of production methods, and a continued and expanded pooling of results and resources for research, were first essentials in the introduction of mechanisation in the rice production field.

Simple equipment

Further valuable information on the snags as well as the possibilities of mechanisation was provided when the International Rice Commission met in December last in Calcutta. There, emphasis was especially laid on the importance of developing better hand tools and simple equipment within the rice-growing countries themselves. Not only is any more advanced form of mechanisation far beyond the means of the growers, but there is also a more or less complete lack of the trained maintenance staff who would be required, for example, with even the simpler forms of power mechanisation. Evidence was provided that tractors and similar equipment may not be used even where they have been purchased, for lack of facilities for maintenance and repairs. Seeding, weeding and threshing were referred to as operations to which attention was being especially paid in the development of new simple equipment.

Further studies

As far as FAO is concerned, the next step was indicated by the Commission's recommendation that an Advisory Group on the Technical Aspects of Mechanisation should be formed, with five to seven members from countries in Asia and the Far East, and two to three from outside the region, thus widening somewhat the area over which information is being obtained and distributed.

Related investigations

At the same time, studies related to mechanisation are being co-ordinated with those of the other groups working under the Commission, such as those on rice breeding, on better use of fertilisers and on the study of soil-water-plant relationships. For example, it is possible that for full advantage to be taken of mechanised equipment, new varieties of rice may need to be developed which are better suited to power harvesting. Fertility studies, too, are closely related to possible new cultural practices, and both of these to the fundamental studies on the biology of the rice plant itself. From every point of view, therefore, it is evident that progress in the mechanisation of rice, the world's most important staple food crop, will be a slow business, intimately tied in with many other aspects of the development of the regions in which it is grown.

Artificial Rain for Sugar Crops

Artificial rain-making and experimental irrigation systems using both overhead sprinklers and furrows are being used to intensify sugar production at Madhvaninagar Estate near Jinja, the second largest town in Uganda.

Although only 150 acres are now under irrigation, it is hoped to extend the scheme to all plantations near Lake Victoria, according to a report in 'Overseas Review', published by Barclays Bank D.C.O.

Uganda's sugar growers closed their 1956 year with three records set in consecutive months. December was a record for any single month with 7,443 tons, breaking the previous monthly record set up in November of 6,802 tons. The year set a new record with 69,037 tons, compared with 65,155 tons in 1955.

THE HAWAIIAN SUGAR INDUSTRY

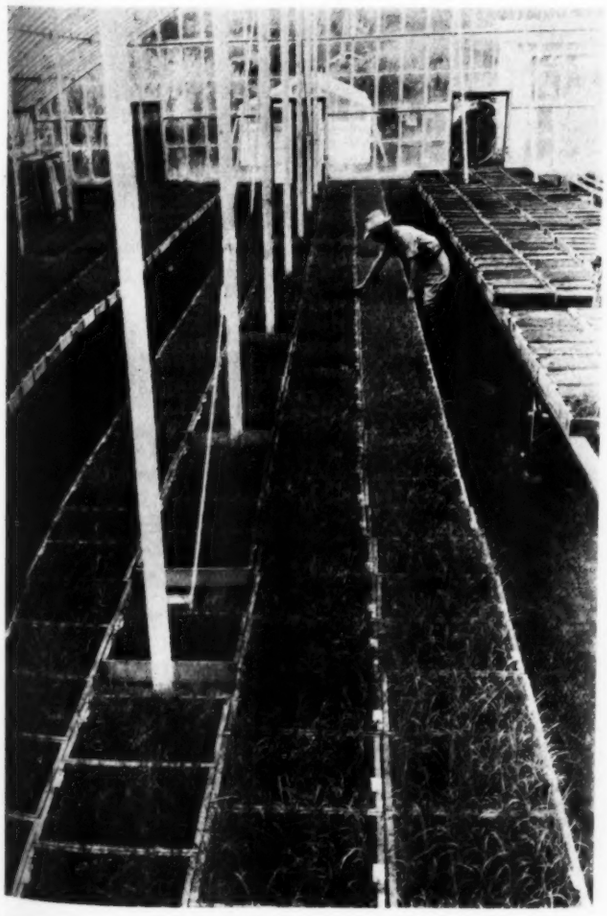
C. E. PEMBERTON

(*Entomologist Emeritus, Sugar-cane Experiment Station, Hawaii*)

The Hawaiian sugar industry has an invested capital of £60 million and it produces an annual crop of sugar worth today about £50 million. It owes its growth and expansion, in fact it owes its survival, to the work of the Experiment Station of the Hawaiian Sugar Planters' Association.

WHEN Captain James Cook came to the Hawaiian Islands in 1778 he found the natives growing sugar-cane in their gardens, but it was not until 1834 that the first commercial sugar-cane plantation was started, which produced in 1835 a total of 2.1 tons of raw sugar. Since then the progress of the industry has been phenomenal. To one who has lived in the islands for the past 44 years and had intimate opportunity to observe this growth and witness the struggle against, and the solution of, the manifold problems that have arisen throughout the years the story is considered a classic in the history of world agriculture. Technology, supported by courage, optimism and abiding faith in the future, has been the major factor in the results we see today.

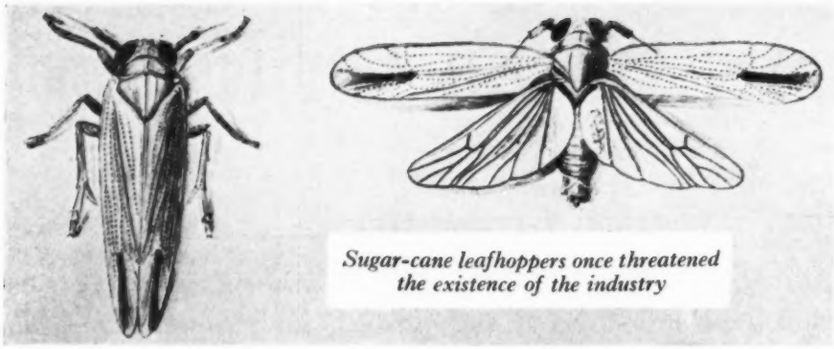
The industry is the largest in the territory, with an annual crop today valued at over $140 million. It gives direct employment on the plantations to some 18,000 persons, who receive a daily wage throughout the year much higher than that in any other sugar-producing region in the world. In addition to those employed on the plantations, many other residents render important services in various ways to the industry and it is estimated that about 50,000 persons in all, with their dependants, gain their livelihood through the Hawaiian sugar industry. This business also pays richly into the economy of the territory in taxes. It now produces about one-fourth of all the sugar milled under the American flag.



Propagation of new canes. About one million seedlings are bred annually

Before outlining briefly the technical services responsible for the remarkable growth of the industry, a comparison of two widely separated periods in Hawaii's sugar history will graphically illustrate the role of scientists in this important business. The sugar harvest of the 1913–14 crop, milled on a partial two-year cycle, was taken from 112,700 acres of sugar-cane. It gave 624,165 short tons of raw sugar. This was a normal yield for that period. The crop harvested in 1955, from cane of approximately the same age, was cut from 106,180 acres of sugar-cane, which is less by 6,520 acres than that of the year 1914, but from it was milled 1,140,112 short tons of raw sugar. Nearly twice as much sugar was produced in 1955 as in 1914 and from a considerably reduced acreage. In the light of present research still further progress is probable. Applied science and modern technology have thus made possible a successful industry in spite of heavy competition with other areas where labour is cheap and production costs are low.

By 1895 there were many plantations in Hawaii producing substantial amounts of sugar, which in 1897 reached a total of one-quarter million tons. This expanding industry increasingly felt the need for technical advice beyond the scope of the practical farmer and in 1895 the planters organised into a non-profit co-operative group known as the Hawaiian



Sugar-cane leafhoppers once threatened the existence of the industry

Sugar Planters' Association. One of the first important acts by this association was the establishment of an Experiment Station, to be financed solely by the plantations. It began with one employee, whose duties pertained to soil analyses and fertiliser studies. Results justified a further development of such a station and the staff slowly grew until today there are 228 members working in many fields of agricultural science. These include departments in cultural practices and soils, plant introduction, chemical research and weed control, insect control, plans and analyses of experiments, mechanisation of field work, breeding and development of new cane varieties, water development, the chemistry of cane by-products, cane diseases, fundamentals of cane nutrition, manufacture of sugar and instruction in field and factory techniques.

Cane varieties

Cane in Hawaii has been grown on the same land for long periods of time. Fallowing or crop rotation is rarely practised, excepting in a few instances where cane land reverts to pasture to be later restored to cane and, in small areas, rotated with pineapples. Though these exceptions have proved beneficial to the land, the bulk of the Hawaiian acreage remains continuously in cane and yields in sugar have slowly increased rather than declined, despite regular cropping on an 18 to 24 months' cycle. However, this has not been possible with any given variety. In spite of elaborate attention to cultural and nutritional requirements, high-yielding varieties ultimately decline and must be replaced with new ones. This varietal decline in yield has been a baffling problem in Hawaii for at least 60 years and still awaits a satisfactory solution. Two classic cases may be mentioned.

In 1854 a cane was imported from Tahiti and given the name ' Lahaina '. It proved to be a highly productive variety. In 1883 decline of this variety was noted in some areas and by 1905 such failure was widespread. It was replaced by a number of other imported varieties, without which the industry would have failed. This demonstrated the need for a continuous programme of varietal change and study. In 1905 the Experiment Station succeeded in germinating true cane seed and a number of seedlings were propagated. One of these, under the name ' H-109 ', became the leading cane within a few years and gave high yields. The industry continued to thrive and grow and by 1929 this variety occupied 117,877 acres. However, under the expanding programme of seedling production started in 1905 and the introduction of commercial and breeding canes from foreign countries, notably from Australia, New Guinea, India, Java and Sumatra, particularly in 1930, the variety 'H-109' was slowly replaced by several varieties that proved superior, and today this wonder cane can no longer compete with the new canes. And some of these are in turn showing signs of decline.

It was in 1926 that a geneticist was employed by the Experiment Station. His contributions resulted ultimately in the establishment at the Station of a Department of Genetics. This Department has proved vital to the prosperity of the industry. Under an elaborate system of seedling production, mostly through crossing and re-crossing of selected varieties to bring out desirable qualities in the progeny, some million new seedlings are now annually produced. By rigid selection the best of these are carefully tested over a period of years at various sub-stations in the islands, under varied soil, elevation and climatic conditions. Canes capable of competing with standard varieties that can be expected ultimately to decline are thus obtained. No cane is suitable for all the varied conditions prevailing on the plantations and the breeding and selection of superior varieties is designed to give canes particularly adapted for each of these different conditions. All of the commercial canes in Hawaii today have been bred at the Experiment Station and no foreign cane has been found that can compete with the present varieties.

Insects and diseases

Insect pests and diseases of sugar-cane can cause losses which may be par-

Photo: U.S.I.S.

Workers using a cane-loading machine to harvest a crop

Photo: U.S.I.S.

Opening a gate to let water from the main irrigation drain into a field irrigation ditch

ticularly serious where production costs are high and margins of profit low. Hawaii has had its share of both. The sugar-cane leaf-hopper, which reached the islands from Australia about 1900, reduced production on some plantations so greatly that the very existence of the industry appeared to be threatened. This led to the establishment of the Department of Entomology at the Experiment Station in 1904. The entomologists solved the problem completely after 15 years of continuous research. Control was effected through the importation of beneficial insects that normally attack this pest in its native habitats.

A number of other foreign insect pests of sugar-cane have appeared in the islands and have been brought under satisfactory control by the same method, but only after extensive exploration and study in foreign countries. No insecticides have been found necessary.

There are at least 200 known insect pests of sugar-cane in various parts of the world. A large number occur in Indo-Malayan and South Pacific areas. It is possible that some may eventually invade Hawaii and require immediate and expert attention. As a safeguard for the future the Entomology Department is maintained and staffed with qualified men. For purposes of essential reference a collection of some half million tropical insects has been assembled by the staff during the past 50 years. This is safely housed and well organised. For additional reference a magnificent entomological library has been built up over the years.

A number of diseases affect sugar-cane in Hawaii, several of which may become serious if not controlled. Specific attention to such diseases began in 1905 with the employment of a trained plant pathologist and the establishment of a Division of Pathology at the Experiment Station. Disease control has been satisfactory through the utilisation of disease-resistant varieties of cane. Before any new variety with promising characteristics is approved for general distribution to the plantations it is carefully screened by the pathologists for susceptibility to any one of several important diseases present in the territory. The high-yielding canes in Hawaii today are thus comparatively free from disease.

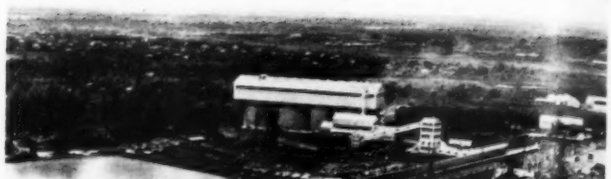
Quarantine

The large number of foreign canes imported for test and for breeding purposes are submitted to a strictly controlled system of quarantine for two years. The sugar-cane quarantine station is located on an island in Hawaii where sugar-cane is not commercially grown. All the importations are carefully studied by the pathologists for evidences of disease during the entire period of quarantine. Should this occur the canes are destroyed. The exclusion of two particular foreign diseases receives special attention. They occur in several countries, one being the Fiji Islands. Danger of their ultimate spread to Hawaii has resulted in the establishment of a testing station in Fiji, where all commercial or new canes of promise in Hawaii are planted and exposed to these diseases. This is a co-operative project by Hawaiian and Australian pathologists. This service presents advance information respecting the susceptibility, tolerance or immunity of Hawaiian canes to these diseases.

Chemistry and weed control

Chemistry has played an important part in Hawaii's sugar economy. The first technical employee was a soils chemist who began work in 1895. Though each of the 27 plantation mills maintains a chemist whose work is vital to the maintenance of efficiency in the factory, the industry is con-

stantly confronted with many problems requiring skilful chemical services and research apart from those of the mill chemist. This work is centred at the Experiment Station, where the Department of Chemistry acts as a general consultant, engages in soil and plant analyses, fertiliser audits and many other activities requiring materials and equipment only available in a well-equipped chemical laboratory. Chemical control of grasses and weeds, together with constant attention to improvement in the mechanics of herbicide application, has impressively increased the utilisation of fertilisers by the cane plant. One of the most important fields of endeavour by the Department of Chemistry is the development from basic materials of improved herbicides, which has resulted in a remarkable control of weeds and grasses. Herbicides are now applied by pressure knapsack sprayers, spray trucks and by aeroplanes, which, in 1951, were also found to be practicable in this work. Another chemical activity of special value involves research with inhibitors of corrosion which may seriously damage containers of herbicides, liquid fertilisers or equipment used in their application.



Bulk storage plant for raw sugar. Belt conveyors move the sugar from the house to waiting ships

Cultural practices

There is a wide diversity of soils on the four islands where cane is grown. This even occurs within individual plantations. Extreme differences in rainfall prevail, where serious erosion may or may not be a factor in soil conservation. Cane flourishes from near sea level to 3,000 ft. elevation and considerable variation in sunshine, temperature and wind duration and velocity is common. About 53% of the cane is irrigated. Under such conditions cultural practices demand the highest degree of agronomic control if profitable crops are to be grown and maintained on the same land from year to year. This has been accomplished and the annual production now averages over 10 short tons of raw sugar per acre milled from about 85 tons of cane. The removal of huge tonnages of vegetative material for processing into sugar necessitates the return of large quantities of nutrients if ensuing crops are to thrive. Commercial fertiliser was first used in Hawaii in 1879, when bone meal was applied on one plantation. Since then increasing amounts of fertiliser, mostly inorganic, have been used to keep pace with efforts to expand production. Constant experiments are under way to predict the requirements for nitrogen, potassium and phosphoric acid. Beginning in 1938, a system was developed for sampling certain cane tissues for analysis to determine nutrient deficiencies or requirements in the fields during the growth of the crop. Known as ' crop logging ', this procedure has become standard practice. It is believed to aid greatly in fertiliser schedules. It also materially assists as a guide to indicate the best time to harvest for maximum sugar return.

Agronomists are also involved in studies of the effects of soil compaction resulting from the use of heavy equipment on the land. Certain highly leached soils have been improved through the application of calcium. Intelligent irrigation management is proving fertile in studies of soil moisture with special physical and electronic equipment. Various types of irrigation flumes have been installed with gradual improvement in the utilisation of available water on the irrigated plantations. Soil erosion has always been a serious problem on some plantations. This is being corrected through altered contouring and arrangement of irrigation lines and in special attention to soil conservation and improvement by returning to the fields excess organic matter accumulating at the mills.

Rat control

Rats have caused substantial losses on many plantations. Cane is a favoured diet amongst the several species of rats in Hawaii. Immense colonies may develop within some of the fields. Special attention to this problem began in 1922 and has continued to the present date. Systematic poisoning has been effective on most of the plantations, but a satisfactory solution of the problem awaits further investigation. Intensive studies of rat ecology and suppression now constitute one of the special projects of the Experiment Station.

Mechanisation

Mechanisation in sugar production is more highly developed in Hawaii than in any other country. Animal-drawn cultivators and hand-hoeing of weeds have been practically eliminated. Cane harvesting by hand is a thing of the past. Mechanised cultivation began in 1910, mechanical loading to cars on portable tracks started in 1920 and mechanised harvesting was first seen in 1937. Harvesting by such means has now progressed to a point where huge machines are being designed to cut and load cane to trucks in one operation. Railway systems to transport cane to the mills have been supplanted by trucks and trailers, some of which may carry 40 tons per load. Planting and fertiliser applications are no longer done by hand and even television control of certain mill operations on two plantations is now in effect, which enables one man to do the work of many. Sugar is no longer assembled in bags, but is handled in mass to be concentrated in large bulk storage houses at seaports for belt removal to freighters, which transport some 95% to the mainland of the U.S.A. for refining. Owing to such high mechanisation throughout the industry, the number of employees required for all operations has been materially reduced and today total employment on the

plantations is almost one-third of that some years ago.

Tassel control

Most varieties of sugar-cane flower profusely when mature. In Hawaii this occurs during the winter months. Deterioration of sugar content then follows. Experiments have indicated that an average loss of about one ton of sugar per acre accompanies flowering. Resulting from studies by physiologists of the Department of Physiology and Biochemistry of the Experiment Station, it was discovered that tasselling could be prevented or greatly inhibited by subjecting ripening cane to strong light for a short period at night during a critical time in September, when cell differentation is starting inflorescence. Practical application of this method to commercial cane fields has not been done, but this demonstrates the intensity of basic research accountable for Hawaii's success in sugar production. Further work in flowering control on irrigated plantations has established proof that tasselling can be prevented by withdrawing irrigation water shortly prior to and during the time when flower initiation takes place. And in other areas where ample rainfall prevents control by this method there has been some success in the spraying of maleic hydrazide or CMU, a du Pont product, on the cane at this critical period to suppress flowering. Other studies by the physiologists have been particularly fruitful in the use of radioisotopes to measure photosynthesis and sugar manufacture within the cane plant and in locating maximum root zones of cane for the application of phosphorus. The Experiment Station was the first agricultural institution to utilise radioactive materials in studies of plant metabolism.

Water

Some of the richest lands in Hawaii have insufficient rainfall for profitable cane culture. However, highly productive plantations have been established on them only after the construction of ditches and tunnels in the wet uplands to convey water to the dry areas, inclined shafts to reach water-bearing rock and deep wells from which enormous quantities of water are pumped. The irrigation systems for Hawaiian plantations are valued at over $44,500,000. Since the invested capital in the Hawaiian industry is estimated at $175 million, water development and use constitutes a major item in its growth and maintenance. To conserve and increase water supplies in the wet mountain areas, the Sugar Planters' Association has taken an active and constructive part in the preservation and improvement of the forest reserves from which all of the water comes. Abundant water for irrigation has been obtained only after thorough surveys and practical recommendations by experienced geologists. This work continues and it is believed that the tapping of Hawaii's water resources is not at an end.

By-products

The possibility of developing profitable by-products of sugar-cane has had special attention in Hawaii. A by-products committee was appointed in 1951 and active work has been under way on this general subject. A method of separating the pith from the fibre in bagasse was devised and pith, in combination with molasses, was tested successfully as cattle feed, which opens a possible future source of food for local dairy herds. Of particular interest has been a study in paper manufacture from the quantities of bagasse available at the sugar mills. After several years of research most of the technological problems associated with the production of paper pulps were solved. Paper manufacture may in time become a profitable business. Fibre board in many forms and grades has already been in manufacture in Hawaii for a number of years.

Thus the perpetuation of the Hawaiian sugar industry, begun on a small scale over 120 years ago, has only been possible through the application of technology developed from research by trained scientists in many fields.

Sixteen Rules for Pesticide Safety *

1. Read the label carefully. Pay particular attention to the warnings and precautions to be taken before opening a container and before each use. Too many users of insecticides disregard warnings, thinking they are exaggerations.
2. Keep pesticides out of the reach of children, pets and irresponsible persons. In the event of an accidental poisoning, call a doctor or get the victim to hospital at once.
3. Always keep pest control material in its original container. Make sure that the container is kept closed and that the warning label is not detached.
4. Never give anyone a portion of pesticide in an unlabelled container. If you do share your pesticide, copy the warning label from the original package and attach it to the new container.
5. After using a container of pesticide, store it in a locked closet or on a shelf that is not accessible to children. Insecticides should not be exposed to extremes of heat or cold.
6. Do not store pesticides where food or feed stuffs are stored or handled.
7. When spraying edible plants, take pains to minimise the amount of spray you get on the edible parts. Be sure the edible parts are thoroughly washed before they are eaten.
8. Wash hands and face thoroughly after spraying or dusting.
9. Do not smoke while spraying or dusting. Pesticides can be transferred to the mouth, resulting in illness or death.
10. Care should be taken to see that the pesticide is not spilled on skin or clothing. If this happens, wash the affected part and change clothing.
11. When using highly toxic pesticides. wear a respirator or tie a damp cloth over the nose and mouth.
12. Wash clothing thoroughly after each spray job.
13. Exercise extreme care when spraying around pets or livestock. Cover their food and water containers.
14. Do not spray near fish ponds or streams when the wind may carry spray and contaminate the pond and so kill the fish.
15. Do not use hormone weedkillers, like 2,4-D or 2,4,5-T, in the same equipment as used to spray pesticides or fertilisers. It is almost impossible to remove all traces of the weedkiller and valuable plants may be killed.
16. When the last bit of pesticide has been emptied destroy the container; there still may be enough residue left to hurt a child or a pet.

* Texas State Dept. of Health — abstracted from Archives of Industrial Health.

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Unloading sugar-cane from Whitlock trailers

SUGAR-CANE BREEDING IN INDIA

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Sugar has been grown in India from time immemorial. Following the protection of the industry in the early 'thirties, there has been a very rapid expansion of the acreage under this crop. India today has four million acres of sugar, which is one-third of the total world acreage.

IT was the grant of protection to domestically-produced sugar in India in the early' thirties—during the period of British rule—which led to the rapid expansion of the sugar industry, the establishment of sugar factories and the cessation of imports of sugar.

About four and a half million tons of raw sugar are now produced for domestic consumption, mostly from sugar-cane. The product is consumed just as it comes from the sugar factories without being reprocessed in a refinery, and it is produced in three forms: jaggery, khandsari sugar and white sugar.

Jaggery, the crudest form, is simply cane juice which has been boiled down and solidified. The juice is extracted by crushing the cane in small three-roller mills and the liquid expressed is then boiled down in open pans, with lime added as a clarificant. The product so obtained is a mixture of crystalline sugar and the non-crystalline molasses and contains only about 60% of sucrose. This is an important cottage industry, as over half of the sugar grown in India is processed in this way.

Khandsari sugar is obtained by separating the molasses from the sucrose. The output is small because the industry is confined only to certain parts of north India. White sugar is produced in certain factories; it is not subsequently reprocessed, but is used for immediate consumption in this form.

The main reason why the sugar industry is confined mostly to the Indo-Gangetic plains of north India was the collapse of the indigo industry following the discovery of synthetic indigo. This accident in history led to the concentration of sugar growing in the north, where it was planted in the areas previously under natural indigo.

This unplanned establishment of sugar as a major industry had unfortunate consequences, as the climate of the sub-tropical north is not suitable for growing the best varieties of cane. Because of the extremes of temperature and the short time for growth, the north Indian canes are short and thin. These are the variety *Saccharum barberi*, named after Dr. Barber, the father

of sugar-cane breeding in India. The canes of the tropical south, the so-called ' noble ' canes, *S. officinarum*, are tall, thick and sturdy, because there is the whole year for growth and development to maturity. No part of this region is unsuitable for the crop; the limiting factor is the availability of water for irrigation. The difference in stature and thickness between the two varieties is illustrated in Fig. 1.

Since more than 80% of the cane lands are in the northern half of India, where yields may be as low as 10–12 tons per acre, the overall average for India is naturally lower than if there had been a greater concentration in the south, which is, indeed, the correct habitat for the crop. Here the usual time for planting is December–March and the crop is harvested from the tenth month onwards, the early-maturing varieties being crushed first. Where irrigation is possible, the crop is planted in July and it becomes, in effect, a two-season crop, with a proportionate increase in yield.

An important factor to be taken into consideration is the fact that the cane is paid for by weight and not according to sucrose content as in other countries. The reason for this is the small size of the individual properties and the consequent small size of the transactions.

Breeding

Compared with other crop plants, the improvement of sugar-cane through breeding is of comparatively recent origin. Work was begun towards the close of the last century with the discovery, made independently in Java and Barbados, of the fertility of sugar-cane seeds. Since then breeding work has been vigorously pursued in Barbados, in Java, in Hawaii, and at Coimbatore in India, among the older stations, and at Canal Point, U.S.A., among the more recently established. Inter-varietal, inter-specific and, to some extent, inter-generic hybridisation have played a prominent role in sugar-cane breeding. The emphasis, however, has varied from one country to another in respect of the appropriate species of *Saccharum* used in hybridisation. In Java the indigenous *S. spontaneum* (glagah) has been extensively used and, to some extent, ' chunnee ', a form of the Indian *S. barberi*. In India, Barber employed the Coimbatore form of *S. spontaneum* in 1912–14. The evolution of Co 205, a direct hybrid from the cross *S. officinarum* and *S. spontaneum*, proved epoch-making in that it could immediately be released for cultivation in north India. This, indeed, paved the way for the establishment of the industry on sound lines.

While *S. spontaneum* imparts desirable characters, e.g. vigour and disease resistance, it does not however improve the quality of the juice. This can be done by progressively increasing the dosage of the ' noble ' blood in the hybrids by repeated back-crossings with *S. officinarum* and its derivatives.

Fig. 1. On the left is north Indian thin cane, S. barberi, *and on the right south Indian ' noble ' cane,* S. officinarum

By this process of ' nobilisation ', which is, however, ineffective beyond a certain level, there have been built up a large number of bi-species and tri-specie hybrids, many of which have been released for general cultivation. The majority, however, are being employed to swell the genetic stock and are used as parents, as they possess desirable characters whose synthesis through judicious hybridisation is the main objective.

It is a remarkable fact that within a period of 50 years hybrid canes have completely replaced the original varieties in their respective countries. The transformations effected through breeding are spectacular. The photograph, Fig. 2, shows the magnitude of the improvement by comparing Co 419 with *S. officinarum*, which it has completely replaced in tropical India. Equally remarkable, however, is the fact that even after half a century sugar-cane breeding is still a matter of chance. To understand the reason for this a brief reference to the genetical constitution of the sugar-cane is necessary.

Cytogenetical basis

All breeding work to be sound must be based on a genetic understanding of the material involved. The genetical data are traceable to the behaviour of chromosomes on which are located the genes which transmit the hereditary characters. Each constituent cell of the plant contains strings of chromosomes and the number of chromosomes in each for any particular species is the same. Propagation in sugar-cane is vegetative, except in breeding work, where seedlings are raised through hybridisation and seed formation. The so-called varieties are clones, in each of which the genotype is fixed; that is, the chromosomal make-up of each individual is fixed and remains unchanged, being passed on unaltered from generation to generation.

The daughter plant arises from the growth of the bud (' eye '), which is situated one at each node of the ' sett ', which is a piece of sugar-cane stem two or three internodes long. Repeated cell-divisions in the bud give rise to millions of cells accompanied by tissue differentiation. Whatever may be the number of divisions, the fact is that the same number of chromosomes is maintained through a process of longitudinal splitting of each chromosome, the divided halves going to different daughter cells and never to the same cell. With this division there is no change in respect of the quality, number or arrangement of the genes in the new tissue. The consequence is that the new plant which is composed of these cells is an exact replica of the mother.

In sexual reproduction which leads to ultimate seed formation, there occurs during the formation of the reproductive cells—the egg and the sperm—not only a numerical halving of the chromosomes in order to com-

pensate for the doubling at fertilisation, but also a qualitative change inasmuch as exchanges of genes are taking place between the parental chromosomes, constituting the somatic chromosome complement. When such qualitatively altered chromosomes come together at fertilisation a reshuffling of parental characters occurs. The daughter individual starts life as a single fertilised egg cell in which have been brought together the paternal and maternal chromosomes. By the repeated equational divisions of this cell there is built up a plant, the cells of whose body contain the doubled or diploid number of chromosomes. Fig. 3 shows diagrammatically the chromosome cycle in the life history of sugarcane. Variations, inevitable as they are in any sexually-produced progeny (except in the selfed progeny of a true-breeding form), are very numerous in sugar-cane. Such a genetically impure form is said to be ' heterozygous ', having been derived from the union of sexual cells, dissimilar in respect of the quality, quantity and the arrangement of the genes.

A phylogenetic study of the sugarcane has shown that in the distant past, through natural hybridisation between two or more forms, and that, at different periods in its evolution, not only has there been natural inter-crossing, but also repeated chromosome duplications. From its cytogenetic constitution sugar-cane is a highly heterozygous (genetically impure) polyploid complex (having duplicated sets of chromosomes). Thus the ' noble ' cane, of which there are 150 varieties, is an octoploid, with 80 somatic chromosomes, derived from a basic number of 10.

It is around this fundamental of its cytogenetical constitution that the breeding pattern has to be woven and the breeding behaviour interpreted. Firstly, owing to its high genetical impurity and polyploidy, the selfed progeny shows a wide range of variations from which it is almost impossible to recover a pure-breeding line, as in other crop plants. Also, in many sugarcanes, especially in *S. officinarum*, there are no survivors in selfed populations, owing to the presence of a large accumulation of lethal genes. For the same reason, among a hybrid population, one finds the parental characters distributed in an unexpected manner. If in such a heterogeneous medley of first-generation hybrids we are able to spot a form in which there is an optimum synthesis of the desirable qualities, it is fortunate that it can be multiplied vegetatively. Otherwise such a seedling obtained by a mating of highly heterozygous individuals can neither be re-synthesised, nor can it be used to recover a pure-breeding type through seed formation. That is why thousands of seedlings are raised through hybridisation in the expectation that the larger the number, the greater the chances of getting a form to meet requirements.

Although the presence of several sets of genetically impure chromosomes in the complement makes it difficult to apply traditional methods of breeding, it confers the advantage of a wide cross-ability. In consequence of this, crosses between such widely differing parents as sugar-cane and bamboo, and sugar-cane and sorghum, are possible. The failure of a cross is primarily due to the inability of the two parental sets of chromosomes to co-exist owing to their incompatibility, in which case there would be no hybrid formation at all. Even if they can remain side by side, they would fail to pair during the reduction division and without such pairing no formation of reproductive cells can occur. Even though a hybrid might be formed out of such a cross, it would be sterile. To some extent this is overcome by the parental sets of chromosomes undergoing duplication so that each chromosome has its own duplicated counterpart with which to pair. This internal pair-ability (autosyndesis) confers fertility on hybrids which would otherwise have remained sterile.

Maternal inheritance

In many crosses there is a preponderance of maternal characters which make the hybrids closely resemble the mother. For instance, when the thick ' noble ' cane is used as the mother and the thin north Indian cane as the father, the hybrids are thick and tall like the mother. In the reciprocal cross with *S. barberi* as the mother the hybrids are thin and short. Such crosses would normally be reciprocally identical.

Fig. 2. Old and new sugar - canes: on the left is a planting of the improved variety Co. 419, compared with the ' noble ' cane, S. officinarum, *which it has replaced completely in tropical India*

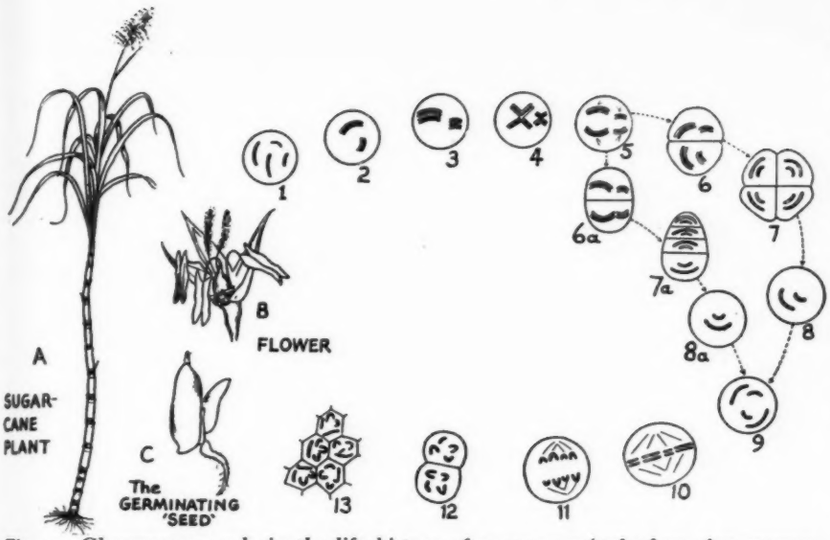

Fig. 3. Chromosome cycle in the life history of sugar-cane (only four chromosomes shown)

1 *Somatic cell (2n = 4)—two paternal (black) and two maternal (white) chromosomes*
2 *Pairing of homologous chromosomes*
3 *Each chromosome divided into two chromatids*
4 *Crossing over between two non-sister chromatids*
5 *I Division (reductional) separation of the chromosomes*
6 *Dyad on the pollen side, each cell having two chromosomes*
6a *Dyad on the egg side*
7 *II Division (mitotic) tetrad of pollen grains, each having two chromosomes*
7a *Linear tetrad*
8 *Sperm*
8a *Egg*
9 *Fertilised egg having four chromosomes*
10 *Mitosis—each chromosome divides longitudinally into two chromatids*
11 *Separation of the chromatids*
12 and 13 *Multiplication of cells by mitotic division of the nucleus*

While this phenomenon involves easily recognisable characters like height, colour and thickness, it has also been found to hold good for sucrose content and purity. The implication from this is that the utmost care needs to be exercised in the selection of the female parent.

Parthenogenesis

The formation of a daughter individual from an egg, which has had no contact with the sperm, is a common feature in sugar-cane. This phenomenon of parthenogenesis has been found to be useful in the breeding of new types of sugar-cane. Since heritable variations are the foundations on which the breeder builds his edifice, the part that parthenogenesis plays cannot be ignored. The egg, like the sperm, contains half as many chromosomes as the body cells, having been formed through the reduction division. As such, a plant produced from an egg which has had no contact with the sperm may be expected to show the same reduced number of chromosomes as the egg. But in sugar-cane it contains the somatic number. The manner in which the egg comes to possess the doubled number of chromosomes, even without fertilisation, is usually through a suppression of the reduction division, which ordinarily leads to the formation of a normal egg containing the halved number. The exchanges of genes between parental chromosomes which take place during this division having been skipped, the parthenogenetic forms are replicas of the mother. In sugar-cane, however, the diploid egg comes into being, not through an obliteration of the reduction division, but by some process which takes place after that division. In consequence, even though there has been no fertilisation, there is something else substituted which brings about not only a duplication of the chromosome number, but also the usual reshuffling of characters. Though formed parthenogenetically, the daughter individuals differ among themselves and from the mother. Hence they are as useful as plants derived through hybridisation for breeding purposes. Many economic canes, once regarded as hybrids, are now known to have been formed parthenogenetically.

This is not all. Because of the presence of several duplicated sets of chromosomes in the sugar-cane complement, even the loss of a number of chromosomes through some aberration does not affect its survival. In normal plants even the loss of a single chromosome may prove lethal. Elimination of chromosomes *en bloc* during the formation of reproductive cells, especially the egg, is of frequent occurrence in sugar-cane. Such deficient eggs not only function parthenogenetically, but also take part in fertilisation. The resulting individuals show chromosome numbers very different from the expected ones. Fig. 4 shows seedlings derived from the functioning of normal and deficient eggs in the same cross. Cytological features of this kind increase the part played by chance in the production of desirable types. While it may not be possible to predict with accuracy the results of a cross, a sound knowledge of the cytogenetical peculiarities will help in drawing up a breeding programme.

Fig. 4. Seedlings of cross between S. robustum *and* sclerostachya : *functioning of different chromosomed eggs in the same cross*

Left to right:
S. robustum = 2n = 84
P'801/43 = 2n = 53 (38 + 15)
P'801/1 = 2n = 55 (40 + 15)
P'801/57 = 2n = 57 (42 + 15)
Sclerostachya = 2n = 30

Breeding operations

Hundreds of thousands of seedlings are raised annually through hybridisation, as also through parthenogenesis. Sugar-canes do not usually flower in north India and even if flowers do emerge no viable seeds are set. That is why the Breeding Station is in south India, where the climate is more suited to breeding operations. Seedlings which are raised in pans are transferred to the first ground nursery after the third month and to the second ground nursery after a further three months. There the seedlings are selected mainly on the basis of vigour and those selected are transferred to the one-row trial plots. Selections from these are taken to the final test plots, where they

undergo replicated trials. Data on yield, sucrose, purity and flowering percentage are calculated from the tenth month onward up to about the sixteenth month. Time of maturity is of great importance, especially in the tropical south, where canes can be planted during almost any time of the year. A planned sequence of these successively maturing canes would extend the crushing season in the factories. Indeed, there are quite a few factories in the south in which crushing is carried on almost throughout the year.

Out of the hundreds of thousands of seedlings raised through hybridisation, selfing etc., by the time they reach the final test plots their number is reduced to less than 100 and the time interval is about three and a half years. Between 20 and 50 of these are finally selected on the basis of their performance, are raised to Co (abbreviation for Coimbatore bred) status and are distributed to the various States for trials in their respective stations. The soil, weather and other conditions are so different in the different parts of the sub-continent that it is necessary to ascertain the performance of the canes in the various environments. It has often happened that a cane that does well in one area does not do so well elsewhere. Those that do well, after a number of years of trials in the respective tracts, are finally released to the cultivator. Although the number of Co canes runs to well over a thousand, the number released to the cultivator is only a fraction of this number. The majority of those retained are employed as parents for hybridisation and for ' selfing '.

Discussion

The breeder can evolve varieties having the basic quality of higher yield, which is dependent on its ability to use soil nitrogen. This alone would be of little use if proper attention were not paid simultaneously to soil and its husbandry. With the arrival of a number of seedlings year after year the old idea of a general performance variety must recede to the background. Each seedling may be expected to give of its best under a particular set of environmental conditions. The testing of the seedlings in State experimental stations is a step towards this objective. The environmental conditions suitable for a variety would gradually become more and more specialised, with the result that newer varieties would have to be bred for increasingly narrow tracts. A variety which at present may serve a comparatively large area will have to yield place to a number of newer varieties adapted to narrow ranges of environmental conditions within the original tract. Obviously the emphasis must shift from breeding canes merely for higher yield and sugar content in which there can be no more spectacular increase to breeding varieties of greater numbers for special regions or tracts. A quicker method than this time-consuming process would need to be applied to predict the potentialities even at the seedling stage, not only of the yield of sucrose, but also of the differential response shown by them to different environmental conditions, through chemical analyses and study of growth and periodicity in the seedlings.

Silent Devastation

According to the managing director of E. H. Bentall and Co., over eight million tons of steel are wasted annually in Britain through the corrosion of farm machinery. Mild steels and high-grade alloy steels are all liable to attack and it is, so far, not possible to produce a ferrous metal that is immune. One answer is a lasting coating of the working parts to give a high degree of protection.

One of the most vulnerable machines, by nature of its purpose, is the fertiliser distributor, which must be able to withstand the corrosive effects of superphosphates, sulphate of ammonia and muriate of potash, etc. It is well known that much damage is often caused through the mechanism becoming blocked by the hardening of the fertiliser, resulting in damage to the mechanism when it is again set in motion. However, the design of the machine is one of the most important aspects so far as corrosion is concerned, for the parts most exposed to corrosion must be easily dismantled and cleaned. If the machine can be easily washed down, the cause of corrosion is removed.

Corrosion tests on a range of ferrous and non-ferrous materials with special regard to the corrosive effects of artificial fertiliser

Material	*Analysis and treatment*	*Effects of superphosphates, sulphate of ammonia, muriate of potash etc.*
Mild steel	Untreated, bright surface	Badly attacked, leaving a thick covering of rust
Valve steel EN51	.3% C; 3% Ni; .3% Cr hardened and tempered	Badly attacked, leaving a thick covering of rust
Valve steel EN52	.45% C; .5% Ni; 8.5% Cr hardened and tempered	Slightly rusted
Valve steel EN59 (XB)	.79% C; 1.4% Ni; 19.75% Cr hardened and tempered	Very slightly rusted
Valve steel EN54(KE965)	.42% C; 10% Ni; 14% Cr; 3% W austenitic	Very slightly rusted
Stainless steel EN58 J	.07% C; 9.5% Ni; 17.75% Cr; 2.6% Mo austenitic	Very minutely pitted
Mild steel	Sherardised (zinc coating)	Etched black
Mild steel	Electro - galvanised (zinc plating)	Slightly discoloured
Mild steel	Cadmium plated	Badly attacked in areas where only a thin coating is present
Mild steel EN32	Chromium diffused	Attacked through chrome case extensively
Mild steel	Chromium plating	Badly attacked in areas
Mild steel	Ionex plated	Very good resistance
Aluminium	The precise analysis of the non-ferrous materials was not considered relevant	Pitted
Copper	See aluminium	Discoloured dark brown
Brass	See aluminium	Etched similarly to wet attack (black)

RICE IN SPAIN

J. EDWARD THOMAS
(*Formerly Editor*, WORLD CROPS)

Rice yields in different countries of production vary from over 3,000 lb. per acre in Spain to about 500 lb. in Tanganyika. The high yields in Spain have been attributed to careful transplanting; to the use of 'japonicus' in preference to the 'indicus' species; to heavy application of fertilisers and to the almost loving care given to the crop during its cultivation.

IT is generally conceded that the cultivation of rice was initiated in Asia; it has since been extended to many other parts of the world. Many rice-growing countries depend on rice for their very existence and it is interesting to note that it is the basic food for over 1,000 million people—nearly half the present world population.

Rice was introduced into Europe by Alexander the Great, but it was at first only cultivated on a small scale. Later the Arabs, who had known it in Asia, introduced the crop into Egypt, North Africa and Spain. In Spain it was at first grown only in the Province of Seville, but later its cultivation was extended to the Mediterranean littoral and it came to acquire extraordinary importance in the Province of Valencia.

Spanish varieties

In any plan for the better production of rice it has to be remembered that, whereas some varieties are better suited to one set of conditions, other varieties produce better under other conditions of soil and climate; but this knowledge of the performance of varieties can only be determined on the basis of trial and error. In Spain, for example, where one of the most generally cultivated varieties is Bomba, it has been found that, although this was at one time of leading importance in the Province of Valencia, it is now found to be better suited to the Provinces of Albacete and Murcia.

Bomba.—This variety is characterised by its tallness, reaching a height of 1.4 m., but it is susceptible to disease. The yield of a healthy crop is of the order of 4,000 to 4,500 kg. of rice in the husk per ha. Bomba is a good-quality kitchen rice and so is frequently adulterated before sale with rice of lower quality.

Bombón.—This is another variety that is grown widely in Spain, particularly in the Marina (Alicante) region. It grows to a height of 1.45 m., has a vegetative cycle of between 150 and 160 days, and the method of propagation is to sow in nurseries and transplant the seedlings.

Amonquilí.—This variety gives high yields, but is not of good kitchen quality. It grows to a height of between 0.96 and 1.18 m. It also is transplanted.

Originario Benlloch.—This variety came to Spain from Italy. It is of high quality, stores well and grows to a height of about 1.15 to 1.3 m. Its yield is of the order of 7,200 kg. per ha. The cleaned rice is crystal white in colour and breaks with a vitreous fracture. It is transplanted in May and is harvested in September.

Americano 1,600 or *Colusa.*—This variety was obtained by selection from *Originario Benlloch* and exhibits good resistance to common rice diseases. The plants reach a height of 1.15 m. It is sown in March, transplanted in May and harvested in September. The variety was introduced in 1923 and is grown widely in the Provinces of Valencia and Tarragona.

Sancino, Precocious No. 6.—A sub-variety of *Originario Benlloch.* This variety adapts itself very well to fertile and compact soils. The yield of this sub-variety is about 6,300 kg. per ha. when grown under the best conditions.

E.A.S. No. 1.—Selected from long-grained *Americano* 1,600. The plants reach a maximum height of 1.26 m. The grains are very vitreous and hard and 100 grains weigh 3.13 g. Its vegetative cycle is some 10 days in advance of *Originario Benlloch.* With good conditions, it gives a yield of 6,500 kg. per ha.

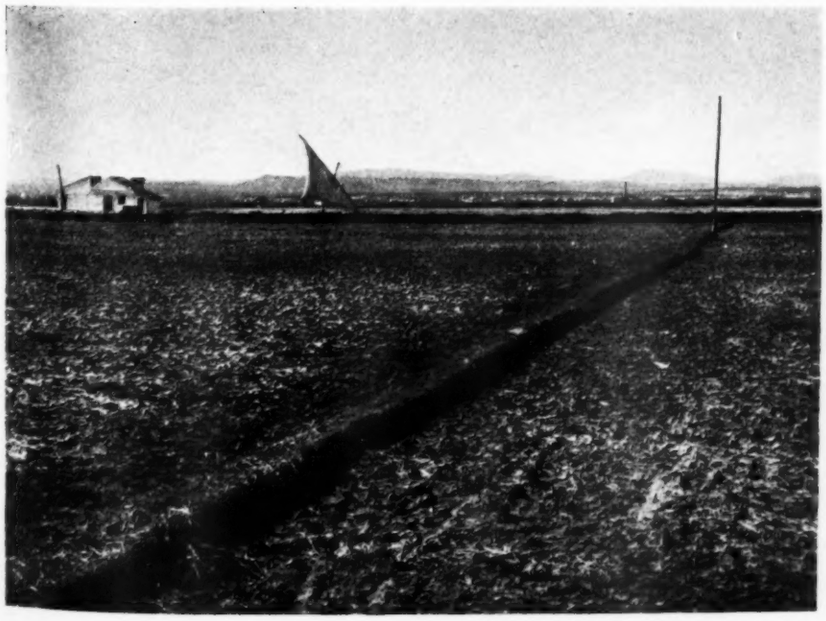

Photo: Spanish State Tourist Office, London

Rice fields in the plain of La Albufera, Valencia, awaiting cultivation. The canal serves a dual purpose—transport and irrigation

Precoz Amarillo.—This variety of rice is derived from *Originario* and, as its name indicates, it maintains a strong yellow colour during growth. This characteristic is advantageous in that it permits weeds to be recognised during the growth cycle. The plants of this variety reach a height of 1.1 m.

Bombilla.—Another variety which is much cultivated in Spain, particularly in the region of the Ebro, and has many of the features that belong to *Benlloch.* It grows to a height of only about 1 m. The characteristic of this variety is its great resistance to disease. Its growth cycle approximates to that of the variety *Originario.*

E.A.S. No. 2.—In the quality of the grain this variety is similar to *Bomba* and it achieves a height of 1.22 m. *E.A.S. No.* 2 is strongly resistant to disease and returns good yields. When grown in conjunction with chemical fertiliser treatment it yields about 7,200 kg. per ha.

Saigón.—In the quality of the final product, this variety is similar to *Originario.* It grows to a height of 1.5 m. It produces a round rice that is dark yellow in colour and has a coffee-coloured beard. When mature the colour is almost black. The vegetative cycle is of the order of 130 days.

There are many other varieties, but these are the most commonly grown.

Climate

Spain is fortunate in that her chief rice-growing areas have a climate which is particularly favourable to this crop. Rice requires a warm or even hot climate for proper growth and surface and soil temperatures are also important factors. For germination the plant needs a minimum temperature of 12–13°C.; for flowering, 22–23°C.; and for grain formation, some 19° C. This cereal requires zones where temperatures are high during spring, summer and autumn. Light, too, is an important factor for effective functioning of chlorophyll and sufficient heat and light are necessary during the 140 days or so of the vegetative cycle.

As for water, the rice plant is very demanding: it is perhaps true to say that it is the only cereal that is cultivated under conditions of inundation. Therefore water and humidity are other important factors for its growth.

Rice is extremely susceptible to frost, and a common method of overcoming this danger in Spain is to build protective covers of esparto grass, which, in this country, is abundant and cheap.

Soil

Burriel and Aleixandre have studied the rice soils of Spain, particularly the soils of the plain of Turia and the Ebro delta. Their determinations show that the rice-field soils in these areas are highly calcareous, 30–48%, and that the clay fraction is predominantly illite. The quantities of total P_2O_5 and K_2O vary between the following limits: P_2O_5, 84–231 mg. per 100 g. of soil; K_2O, 1–2.7%.

The corresponding figures for assimilable P_2O_5 and K_2O are P_2O_5, 4–23 mg.; K_2O, 30–64 mg. per 100 g. of soil.

The values of assimilable P_2O_5 are low and this might be one of the reasons for the decrease in yield which became manifest in the early part of this decade. However, it seems that assimilable phosphorus does not play as important a part in calcareous soils as was once thought.

The quantity of clay in the soil in the regions cited above is better in the rice fields that are situated nearest to the source of the irrigation waters. This clay fraction is rich in nutritive elements and this largely explains the better yields obtained in these zones.

Method of cultivation

The system of cultivation followed is by transplanting from nurseries, which are about one-twelfth of the area to be planted. These nurseries are established in well-watered and sheltered places and, of course, in the most fertile soil.

In order to improve the soils which are to receive the young rice plants, the ground is fertilised with much green manure; the soil is usually prepared in October and the selected plant which will serve as green manure is sown by hand. When this plant has achieved maximum growth it is mown, primarily to facilitate the subsequent ploughing, harrowing and grading.

Sowing in nurseries.—The seed is mechanically selected and disinfected in a 0.5% solution of copper sulphate for a period of two to four hours. This steeping in copper sulphate solution is also helpful because it helps the germination of the grain. When the seed is disinfected in the dry it is usually steeped in water for 12 hours afterwards.

The nurseries are sown with the rice in March and April, the seed being distributed as evenly as possible by hand. The area is then flooded and the water is maintained at a constant level.

The proportion of seed sown depends on the quality of the soil, the climate, the variety of rice, the time of sowing etc.; in ideal conditions about 400 kg. of rice is sown per ha., although at times 600 kg. may be sown.

Photo: Spanish State Tourist Office, London

Cultivating a rice field in Valencia

Photo: Spanish Embassy, London

Transplanting rice. The seedlings are planted with almost geometrical precision

Horse and sledge harvesting rice

Photo: C. R. Freemantle

At this stage great care is necessary to ensure that water is maintained at a reasonably high level, and much attention is also given to combating the weeds that grow in association with the rice. The most dangerous growths at this stage are the algae. To exterminate the algae the most effective and most widely practised method is to allow the nursery bed to dry for a period of three days.

Chemical fertilisers are also utilised. It is common practice to incorporate 350–1,000 kg. of sulphate of ammonia per ha., the quantity varying with the type of soil, but the quantity is also influenced by the temperature of the zone. For example, massive applications are given if the temperature remains low, in order to stimulate the growth of the plants. Use is also made of superphosphate. Generally, however, there are only two applications of chemical fertilisers: one in the month of seeding and another on the day before lifting for transplanting.

In areas where there is an infestation of aquatic animal life 2,500 kg. of quicklime per ha. are added to the soil at the same time as a leguminous green manure. When lime is thus applied it is the custom to add 600 kg. of a mixture of equal parts of superphosphate and sulphate of ammonia per ha.

Transplanting.—When the young rice plants reach a height of 20 to 25 cm. they are lifted by hand and are shaken carefully to loosen the soil.

The number of plants produced varies with the variety that is planted, the amount of fertiliser used, the climate and necessarily with the amount of attention given to the crop before and after planting. It has been observed that the optimum temperature for growth at this stage is about 18° C., but even if it is a little warmer this is not prejudicial to the growth of the young plants.

The areas to be planted with the young rice plants are carefully prepared; the soil is ploughed to a depth of some 15 cm. some time before in order to ensure proper aeration of the soil and an increase in nitrifying bacteria and to encourage the humus to break down.

In some Spanish rice-growing areas, such as in Valencia, wheat is sown in October and if the ground is poor recourse is had to chemical fertilisers (360 kg. of sulphate of ammonia and an equal quantity of superphosphate). They sow 70 kg. of wheat per ha., which is harvested in mid-May.

Finally, when the ground is cleared, levelled and prepared and the bunds have been consolidated so that water is maintained at the required level, the rice seedlings are transplanted. Then the field is inundated.

Care after transplanting.—The important processes that remain are the replacement of failures, weeding and fertilising.

Little use is made of chemical weed-killers because, for the most part, all the weeds are removed by hand.

It is important to note that by planting the best varieties, by improved methods of cultivation and by the use of fertilisers, Spain has arrived at a point where she produces perhaps the highest yields per ha. of rice in the world.

Before the rice farmers of Valencia began to use chemical fertilisers they obtained yields of only 1,150 - 1,300 kg. of rice per ha., but when use was made of Peruvian guano yields rose to 3,850 - 4,200 kg. per ha.

Water management.—Of extreme importance is the correct control of water. In Spain, as in other countries, the amount of water required depends largely on the type of soil. For example, Valencian clay-type soils require about 2.5 litres of water per second per ha., whereas sandy soils require approximately 10 times this amount.

Some 20 days after the first inundation the ground is drained and dried out. The period of drying depends on many factors, and particularly on the soil type, and varies between five and 10 days. This alternation of watering and drying is continued until the plant reaches maturity and requires no more water. Then it is allowed to ripen. The final period of drying is important because on this depends largely the vitreous state of the grain.

Harvesting.—Rice in Spain is generally harvested by hand. The crop is mown with sickles, made into sheaves and stooked. After some days the sheaves are moved into the shade so as to dry more slowly. It is the custom to shade-dry for about 15 days; after

this, the grain is in a suitable condition for threshing.

Threshing.—Various methods are employed, including tramping with animals (*caballerías*) and fixed and mobile threshing machines.

Threshing is often difficult because the rice is soft-strawed and the stems are difficult to separate from the grain.

Drying.—The next operation is to dry the rice in husk and necessitates the removal of from 4 to 10% of the total weight of the grain and husk as moisture. This, if allowed to remain, would impair its storageability.

The usual method is to expose the grain to the sun on specially built threshing floors, which are sloped to allow good drainage in case of rain. To dry the grain efficiently it is necessary to have a drying area equal to about 5% of the total area cultivated. The grain is turned over and disturbed in various ways to facilitate drying, which is normally completed in about two days; at night the grain is piled into heaps and covered with canvas.

Increasing use is being made of artificial driers, but they are still few in number.

An experienced rice farmer can tell when the process is finished by allowing a handful of rice to fall from one hand to the other because it produces a characteristic noise—*el canto del arroz*. Another practical method is to bite several grains to test the firmness of the perisperm.

Finally, the grain is carried to the storage depôt, cleaned and stored.

Steady progress

In a recent announcement the Spanish Minister of Agriculture reported that between 1945–50 and 1951–56 rice production had increased by 34.9%. This is an indication of the progress made during the last 10 years.

Saving Water in Dams

The evaporation of enormous quantities of water is a very serious problem in many parts of the world where winds and high sun temperatures remove much of the annual rainfall before it can be used. Where the water supply is exhausted before the next rains come, the ensuing drought can have very serious consequences.

In arid tropical regions evaporation may amount to as much as 150 in. a year. In the case of large reservoirs, the total annual losses vary from 10% to 20% of the full total capacity and in small reservoirs of the large farm type losses are rarely less than 40% and may exceed 60%.

On reservoirs in South-West Africa evaporation losses were found to range from 80 in. to 100 in. In East Africa serious losses occur each year from open water surfaces, reservoirs and lakes used for water supplies. Losses generally amount to 4–8 ft. of water, according to the locality, and may be as high as 10 ft. In Texas losses by evaporation from reservoirs are about 7½ million acre-feet of water a year, whereas the State of Texas uses only about 8 million acre-feet a year. The normal loss by evaporation in Australia is estimated to be four times the consumption. There are over 4,000 bores tapping the Great Artesian Basin and yielding a daily free discharge of 350 million gal., but more than 90% of this water is lost partly through evaporation, but also through seepage.

The Mansfield process, which has been developed by C.S.I.R.O. of Australia (see WORLD CROPS, 1957, **9**, 89) provides a simple method of cutting evaporation losses by one-quarter or more.

The almost perfect reflections, slightly blurred by the wind, are produced by an invisible film of cetyl alcohol, less than one-millionth of a millimetre thick, which completely covers the surface of the water (incidentally, the picture is upside down)

The process is based on the fact that a saturated long chain fatty alcohol, cetyl alcohol, spreads a liquid, mono-molecular layer over the surface of the water. The film is non-toxic and retards evaporation, while allowing free passage of oxygen and sunlight. It has been shown that stock can safely drink the treated water and that fish and other forms of aquatic life thrive in it. Wild fowl are unharmed by the film. The film is effective for wind velocities up to 50 m.p.h. It can be damaged by carbonaceous dust and large waves. If ruptured, it will heal itself so long as a reservoir of cetyl alcohol remains in the water.

The success of the process depends on the use of a specific grade of cetyl alcohol, made in uniform-sized beads. Such cetyl alcohol is referred to as SI-RO-SEAL hexadecanol. Price's (Bromborough) Ltd. produce SI-RO-SEAL hexadecanol to the rigid specifications of C.S.I.R.O. They are also supplying the cetyl alcohol used in the solvent method of application.

Two methods of applying this product have been developed. One for small dams, in which the beads of hexadecanol are confined in baskets supported on the surface on rafts; the other for large reservoirs in which the alcohol is released below the surface of the water.

Small dams include station tanks on sheep and cattle farms, domestic tanks where rainfall is stored for cooking and drinking in country districts, and water storages required by fruit and vegetable growers. It is estimated that in Australia alone there are about 100,000 station tanks. Approximately 1,000 rafts have already been built and the process is being increasingly applied in Australia. This year a storage tank at Tennants Creek on the overland route in the arid Northern Territory is to be protected by the Mansfield process. Evaporation losses here are eight times the quantity of water consumed.

On large reservoirs cetyl alcohol is applied dissolved in a volatile liquid. The solution is kept in dispenser tanks, about four to the mile, and released through a pipe below the surface of the water. The flow of small drops is controlled by wind-operated valves, so that the cetyl alcohol is only released down wind. Solvent application of cetyl alcohol has been tested at Stephens Creek, the main water supply for Broken Hill. Evaporation losses here during the dry season are normally four times the consumption rate of 20 to 25 million gallons weekly, a wastage of 80 to 100 million gallons per week. Wastage has been cut by 37%.

Now that these evaporation losses can be cut in this way, it is possible for tanks to be dug to a less costly depth. Since they will be cheaper, it will be more economical for farmers to have more of them and thus increase the head of stock carried.

Nitrogen Fertilisers for Plantation Crops

with particular reference to Ceylon

D. J. HALLIDAY
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Nitrogen is a constituent of protoplasm, of the proteins and of chlorophyll. Signs of nitrogen starvation include reduced plant vigour, yellowing of leaves, and the premature defoliation and necrosis of the older leaves. Then nitrogen fertilisers or manures need to be applied. With sufficient nitrogen, plants increase their leaf surface and so increase their power of carbon assimilation, which is particularly essential during the period of most rapid growth.

OF the trio of major plant nutrients, nitrogen occupies a special position in that four-fifths of the air is nitrogen and there are 30,000 tons of it over every acre. The higher plants, however, are unable to make use of these vast reserves except indirectly through the medium of fertilisers or of certain micro-organisms that have the power of converting free atmospheric nitrogen into a combined form. Some of these micro-organisms are free-living; others grow on the roots of legumes. A small amount of combined nitrogen is also washed out of the atmosphere by falling rain.

History of nitrogen fertilisers

In the nineteenth century the two main sources of nitrogen fertilisers were sodium nitrate, from South America, and ammonium sulphate, obtained as a by-product from coal. The South American deposits, in the deserts of Chile, Bolivia and Peru (formerly mostly in Peru, but since the war of 1879–82 mostly in Chile), were discovered in 1809, but not mined on an appreciable scale until about 1830. By 1840, some 10,000 tons of *sodium nitrate* were being exported annually, a figure that mounted rapidly to over 60,000 tons in 1860, a million tons in 1890 and more than two million tons in 1909.

Ammonium sulphate was made by the Gas Light & Coke Company in England in 1815, but does not appear to have been tested as a fertiliser until about 1840 and did not come into general use until 10 years later.

Potassium nitrate, saltpetre or nitre, is of far older use than either sodium nitrate or ammonium sulphate, but has never attained such an important position in world trade. In 1656 the German chemist, J. R. Glauber, wrote of potassium nitrate, which he called ' Salt of the Earth '; ' Vegetables love it; when growing in the Earth, they thence draw their nourishment, for when the Earth is dead, or void of Salt, it affordeth neither nourishment or increase to seed '. Its manurial value has long been known in the East, particularly in the Indian province of Bihar.

Guano, used as a manure by the early inhabitants of Peru several centuries before the Spanish occupation, was first brought to Europe by Humboldt in 1804, but did not enter world trade until 1840. It became so popular that, by 1870, England alone was importing 280,000 tons a year. By then, however, the richest deposits were exhausted; its quality began to fall off and consumption fell.

There was naturally some anxiety that what had happened to guano might equally befall sodium nitrate. In a presidential address to the British Association in 1898, Sir William Crookes predicted that, unless a new source of fertiliser nitrogen could be found, the world would be short of bread within 30 years. There were ample supplies of nitrogen in the air, but so far no economic method had been found of fixing it and rendering it available to plants. ' The fixation of atmospheric nitrogen ', he said, ' is vital to the progress of civilised humanity '.

Two plots of sugar-cane near Lahore, season 1930–31. Treated plot on the left, control plot on the right

The world did not have long to wait for the realisation of this desire. In 1905 large-scale commercial production of *calcium nitrate* by the arc process was begun by Birkeland & Eyde in Norway and, in the same year, the Germans started manufacturing *calcium cyanamide*, also from the air. A few years later, Haber & Bosch developed the synthetic ammonia process that was to transform the nitrogen fertiliser industry. (In the Haber-Bosch process air and steam are passed over red-hot coke and, after elimination of carbon monoxide and removal of carbon dioxide, the remaining nitrogen and hydrogen are combined at about 500° C. in the presence of a catalyst to form *ammonia*. In the cyanamide process calcium carbide, made by heating lime and coke in an electric furnace, is heated in a current of atmospheric nitrogen, obtained by fractional distillation of liquid air. The arc process depended upon combination of nitrogen and oxygen from the air in a high-temperature electric arc.)

By 1939 nearly 75% of world production of combined nitrogen was fixed from the atmosphere, 17% was a by-product from coal, and Chilean nitrate provided only 9%. The principal producing countries are shown in Table 1.

Commercial nitrogen fertilisers today

The nitrogen fertilisers in use today may be conveniently divided into five groups:

	N, %
(1) The *ammonia* group:	
Anhydrous ammonia	82
Ammonia liquor	20 to 25
Ammonium sulphate	20.8
Ammonium chloride	26
Mono-ammonium phosphate	12
Di - ammonium phosphate	21
Ammoniated superphosphate and ammoniated compound fertilisers	2 to 5
(2) The *ammonium nitrate* group:	
Ammonium nitrate	35
' Nitro-Chalk ', lime ammonium nitrate	15½ or 20½
Ammonium sulphate nitrate	26
Nitrophosphate	12 to 20
Potassium ammonium nitrate	16
(3) The *nitrate* group:	
Sodium nitrate	16
Calcium nitrate	13 or 15½
Potassium nitrate	13 to 15
(4) The *amide* group:	
Calcium cyanamide	20.6
Urea	46
Urea-formaldehyde products	About 40
(5) ' Organic ' wastes:	
Dried blood	10 to 14
Hoof-and-horn meal	10 to 14
Shoddy, fur and leather wastes, feathers etc.	3 to 16
Soot	3 to 6
Guano	7 to 10
Meat and bone meal, meat guano, tankage	4 to 13
Fish meal	4 to 9
Rape dust, linseed meal, castor pomace	5 to 6
Cotton - seed meal, groundnut cake, sediment poonac	About 7
Coconut poonac	About 3
Cattle manure	About 0.4 (fresh) to 1.8 (dry)
Poultry manure	Up to 5 (dry)

The most important commercially are ammonia, ammonium sulphate, ammonium nitrate in various forms, sodium nitrate, calcium nitrate and calcium cyanamide. *Ammonium sulphate*, in particular, is widely used in conjunction with superphosphate and muriate or sulphate of potash in compound fertilisers. Large quantities of *anhydrous ammonia* and ammonia solutions are used in the preparation of ammoniated superphosphate and ammoniated compound fertilisers, chiefly in the U.S.A. There is also a growing interest in the direct use of anhydrous ammonia as a fertiliser, transported in tank wagons and either injected into the soil with a special apparatus, or added to irrigation water. Mono- and di-ammonium phosphates are ingredients of concentrated compound fertilisers. *Ammonium nitrate* in its crystalline form rapidly takes up moisture from the atmosphere; to prevent caking, it is usually sold in the form of coated porous granules or ' prills '. ' Nitro-Chalk ' is a granular ammonium nitrate product which incorporates calcium carbonate, thereby eliminating any risk of fire or explosion and making the final product neutral or alkaline in its effect on soil. Also because of its

Table 1

Annual production of commercial nitrogen fertilisers, 1938 and 1954–55*

Country	*Annual production (thousand metric tons N)*	
	1938	1954–55
Belgium	93.0	245.1
France	196.1	414.0
Germany, Western	354.0	675.0
„ Eastern	478.0	290.0
Italy	109.3	303.5
Netherlands	98.7	290.0
Norway	90.0	194.6
U.K.	123.8	307.0
Total Europe (excluding U.S.S.R.)	1,660	3,130
Canada	49.2	200.0
Chile	223.5	257.2
U.S.A.	240.0	1,651.0
Total North and South America	530	2,180
Japan	256.2	613.4
Total Asia (excluding U.S.S.R.), Africa and Australasia	380	800
World total (excluding U.S.S.R.)	2,600	6,100

*From FAO Yearbook of Food and Agricultural Statistics, 1955.

Applying fertiliser by hand in the West Indies

deliquescence, ***sodium nitrate*** is usually marketed in the form of small, spherical granules. ***Calcium cyanamide*** is used as a weedkiller and defoliant, as well as a fertiliser. *Urea*, on account of its high nitrogen content and ease of solution in water, possesses special advantages for spray application on to the leaves of growing plants, particularly fruit trees. ***Urea-formaldehyde*** products may be described as ' synthetic organics ' that are relatively slow-acting, harmless when applied at heavy rates, and not easily leached away by rain. If they could be produced at an economic price, they might be especially useful in the wet tropics.

Of the organic wastes, ***dried blood***, ***hoof-and-horn*** and high-analysis ***meat*** and ***fish meals*** may be regarded as quick-acting sources of nitrogen and the remainder as slow-acting, most of them providing phosphorus and, in some cases, a little potash as well.

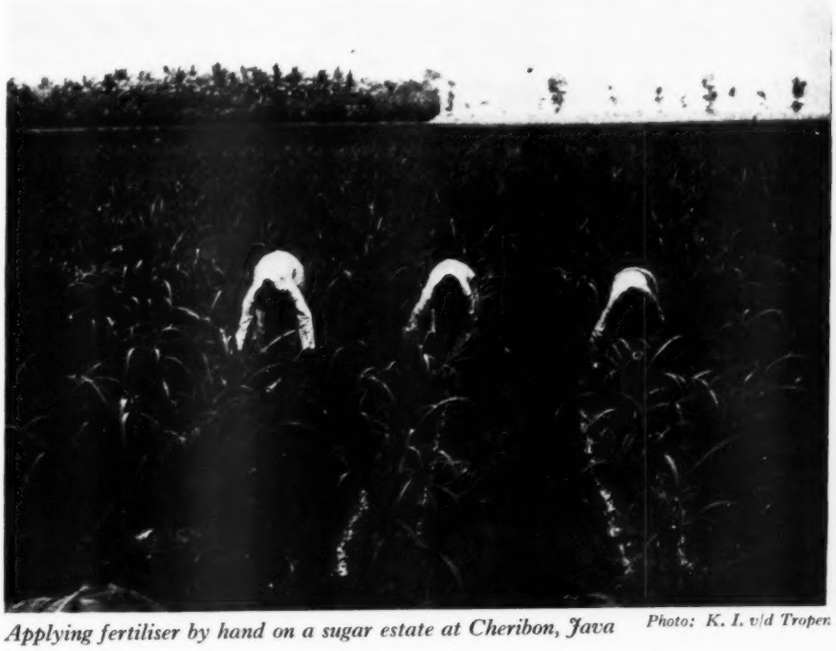
Evaluation of nitrogen fertilisers

In choosing which fertiliser to use, the main factor is the cost per unit of nitrogen, but allowance must be made for the type of nitrogen that is supplied (whether quick- or slow-acting), other ingredients (whether advantageous or deleterious), effect on the acidity or alkalinity of the soil, bulk, storage and mixing qualities, and ease of distribution.

Plant roots are thought to take up virtually all their nitrogen in nitrate or ammonium form, so fertilisers that supply nitrate or ammonium nitrogen are the quickest-acting and the most readily available to plants. Of the two, the nitrate ion dissolves completely in the soil solution, while the ammonium ion becomes attached to the clay portion of the soil and is not so easily leached away by rain. In moist, warm, well-aerated soils that are not too acid, however, nitrifying bacteria quickly convert the ammonium ion to nitrate, so there is little to choose between the two.

Under the same moist, warm, well-aerated soil conditions the nitrogen of dried blood, urea and calcium cyanamide is soon converted to ammonium and thence to nitrate, but under conditions less favourable to bacterial action the conversion may take place more slowly and last several weeks. If calcium cyanamide decomposes too slowly, there is a danger that compounds may be formed that are harmful to young plants and nitrifying organisms. That is why it should be kept in a dry store and well mixed with the soil when used in a seed bed. The nitrogen of other animal and vegetable wastes, not of the same high protein quality as dried blood, takes longer to be converted into the ammonium form, with the result that these fertilisers are slower in their action.

The relative prices of the different sources of nitrogen fluctuate according to economic and political circumstances and the law of supply and demand. In the U.K. in 1939, for example, there was little to choose in price per unit of nitrogen between ammonium sulphate and calcium cyanamide; the nitrogen in sodium nitrate was one and a third times more expensive; that in hoof-and-horn meal, twice as expensive; and that in dried blood, two and a half times as expensive. Today in England dried blood is five to seven times as

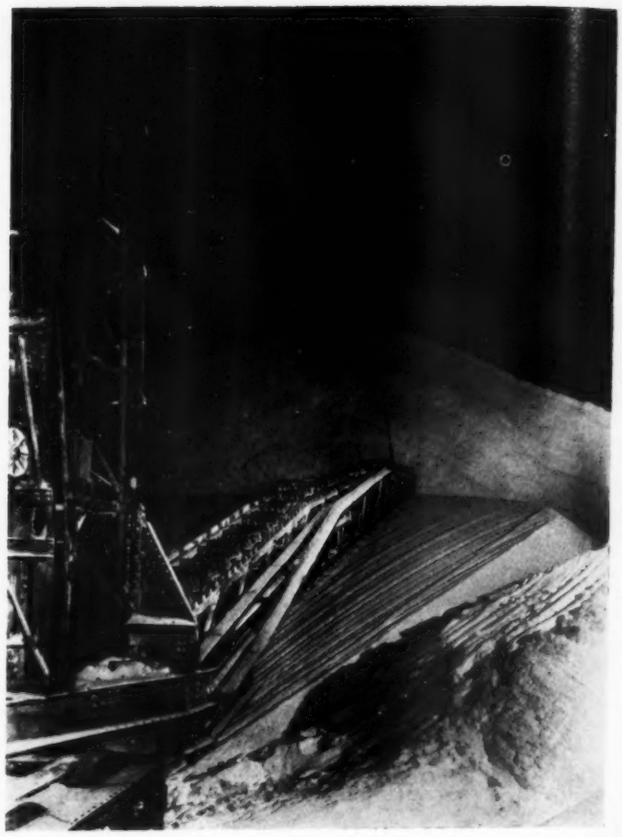


Applying fertiliser by hand on a sugar estate at Cheribon, Java *Photo: K. I. v/d Tropen*

costly as ammonium sulphate; hoof-and-horn, three and a half to five times; and sodium nitrate, twice as costly—all per unit of nitrogen.

For fertilisers containing phosphorus or potash as well an allowance must be made for the value of these nutrients, based on the cost of straight phosphorus and potash fertilisers of similar availability, before computing the unit cost of nitrogen. For certain crops and on certain soils other elements, such as calcium, sodium and sulphur, have an appreciable value, which should be taken into account, whereas under other conditions excesses of these elements or chlorine may be harmful. Some of the bulkier organic fertilisers may provide a useful addition to the soil organic matter.

Sodium nitrate, calcium nitrate, potassium nitrate and calcium cyanamide make the soil more alkaline. Ammonia, ammonium sulphate, ammonium chloride, ammonium nitrate, urea, dried blood, hoof-and-horn meal etc. make the soil more acid. 'Nitro-Chalk' with 20.5% N is approximately neutral; with 15.5% N it is slightly alkaline.



A mountain of ammonium sulphate

Table 2
Nitrogen uptake by certain annual crops (assuming average yields)

Crop	*N uptake (lb./acre)*
Wheat	40
Barley	40
Oats	50
Maize	75
Rice	50
Peas	135*
Beans	135*
Sugar-beet	155
Carrots	115
Potatoes	175
Tomatoes	85
Cabbages	195

*Including nitrogen fixed by symbiotic bacteria.

Uptake of nitrogen by plants

Nitrogen is of major importance to plants throughout their growing season, but particularly at periods of most rapid growth. It is significant that compounds of nitrogen comprise 40–50% of the dry matter of protoplasm, the living substance of plant cells. Nitrogen is a constituent of proteins, which are of great importance in many plant organs, and of chlorophyll, the green colouring matter of leaves. Characteristic symptoms of nitrogen deficiency include reduced vigour, pale green leaf colour, yellowing and dying of lower or older leaves and premature defoliation. Fruit from nitrogen-deficient plants is often small and hard, but of good keeping quality. The average amount of nitrogen taken up by healthy annual crop plants is indicated in Table 2. The gross uptake and net annual removal in the harvested portion of certain plantation crops is indicated in Table 3.

As was pointed out in a previous paper in relation to phosphorus (WORLD CROPS, 1955, **7**, 431), the total amount of nitrogen taken up by plantation crops will be considerably greater than the amount removed in the harvested portion and the actual net removal will depend upon management and how much waste is returned to the soil. In the case of sugar-cane, for example, a crop yielding 40 tons of millable stalks and 25 tons of tops and trash per acre may contain: in the stalks, 45 lb. N, 45 lb. P_2O_5 and 140 lb. K_2O; in the tops and trash, 90 lb. N, 45 lb. P_2O_5 and 125 lb. K_2O; and in the underground portions of the plant, 45 lb. N, 20 lb. P_2O_5 and 20 lb. K_2O per acre. The net removal of nitrogen, therefore, depends very largely upon the handling of the tops and trash. Again, with rubber, perhaps only 3 or 4 lb. of nitrogen per acre may be taken away each year in the latex, but 45 lb. or more are used up in making new growth. An old plantation, therefore, represents quite a considerable invest-

Table 3
Nitrogen taken up and removed annually in produce from certain plantation crops†

Crop	*Gross N uptake (lb./acre)*	*N removed (lb./acre)*	*Portion taken into account*
Bananas ..	160	110	Fruit, one-third of stalk and leaves
Coconuts ..		75	Nuts, leaves and inflorescence
Coffee ..	150	65	Leaves and cherries
Sugar-cane	180	135	Millable cane, tops and trash
Tea ..		55	Plucked shoots

†The figures for bananas, coconuts, coffee and tea are based upon an unpublished literature survey by J. B. Sylvester, Jealott's Hill Research Station, and those for sugar-cane are taken from D. J. Halliday, 'The Manuring of Sugar Cane', Geneva, Centre d'Etude de l'Azote, 1956.

ment in nitrogen. Comparison with the previous paper will show that considerably more nitrogen than phosphorus is removed from the soil by most crops.

Principles of nitrogen manuring

The response to nitrogen is most marked on vegetation that is young and growing rapidly. Because nitrates are so readily leached away by rain, the first principle of nitrogen manuring is to apply nitrogen fertilisers when they are most needed. Even in a temperate climate the efficiency of nitrogen fertilisers, as measured by the proportion of nitrogen that finds its way into the plant, is seldom more than 40–50%; the rest is washed away or denitrified before the plant can make use of it. In a tropical climate correct timing of fertiliser application is more important still.

The second principle of nitrogen manuring, assuming adequate rainfall, is to make the most of green manures and cover crops, such as *Calopogonium*, *Centrosema* and *Pueraria*, not only to enrich the soil with organic matter, but to conserve in a more slowly available form the nitrogen supplied in fertilisers and by nitrogen-fixing bacteria.

Nitrogen manuring of plantation crops in Ceylon

A brief summary of the recommendations from the various fertiliser trials conducted in Ceylon by the Coconut, Tea and Rubber Research Institutes, and elsewhere, may be useful:

Coconuts.—For bearing palms, once every two years: about 0.5 lb. N per palm, preferably as ammonium sulphate or calcium cyanamide. For young palms, an annual application of ammonium sulphate, rising from 0.1 lb. N in the second or third year after planting to 0.25 lb. N six years after planting and thereafter until flowering.

Tea.—Minimum of 36 lb. N per acre annually for a crop of 400 lb., rising to 132 lb. N for a crop of 1,700 lb. per acre.

Rubber.—An annual dressing, rising from $\frac{2}{3}$ oz. N per tree in the first year to 5 oz. N per tree in the seventh and subsequent years.

In every case these should be balanced by appropriate amounts of phosphorus and potash.

Grassland Production

A JOINT meeting of the British Grassland Society and the British Society of Animal Production took place in London recently and the following is a summary of the papers on grassland production, with special reference to New Zealand.

Grassland Production in New Zealand (1) *by J. A. Collier* (*Grassland Research, I.C.I. Ltd.*).

New Zealand is not all highly productive grassland; this paper deals with the conversion of the dense bush into grassland and the improvement of mountainous tussock country.

The individual cannot spend much money on such land, but there are vast schemes financed by Government which, while they will give no immediate return, will do so in the years to come.

In dealing with bush the hardwood is first taken out and then the residual brushwood is crushed and burnt. The crushing operation is carried out by a diagonally-fluted heavy roller, filled with water and drawn behind a tractor. Then the ground is seeded from the air.

Legumes, such as subterranean clover, are established between the tufts of tussock grass, and hills up to 2,000 ft. are reclaimed by reseeding with a mixture of grass, clover and phosphorus by aerial spraying. Such aerial operations are widely practised and are carried out by fixed-wing 'planes and helicopters operating with precision even against slopes of 45°. Not only are fertilisers and seed dropped from the air, but there is also weed control by aerial spraying and fence posts and other supplies are dropped where they are required.

Superphosphate is the principal fertiliser used on the pumice soils and satisfactory results have been obtained by applying molybdenum and lime to the acid soils and also copper in certain areas.

Grassland Production in New Zealand (2), *by E. M. Owens* (*Farmer, Bristol*).

Except for ' town supply ' milk the New Zealand dairy industry is almost wholly situated in the North Island on coastal flats, river valleys and estuaries. Such land is among the most fertile and inherently productive in New Zealand. Soils are mainly volcanic in origin and are often high in potash and phosphate. Trace element deficiencies are common in some areas, especially copper and cobalt.

Many old pastures are in use for dairying and some of the leys are as much as 40 years old, although this kind of thing is more common on the sheep farms than the dairy farms. Although the excellence of many sheep pastures has to be seen to be appreciated, dairy pastures are generally impure swards and are often quite weedy.

This may be the result of a number of factors. So-called medium length grazing, in theory to leave a few inches of leaf on the plant, in practice allows over-grazing of some patches and clumps of coarse grass to develop in others. Further, since all cattle have to be out-wintered, in a climate which is warm enough, but often extremely wet, pugging can be severe.

While potash and phosphate is applied generally and generously, where wanted, nitrogen is rarely used. High outputs of milk per acre often require more nitrogen for the grass than the often weak clovers can produce even in a climate with a long warm summer. Under-grazing may be a contributory factor to both poor clover and under-nourishment of the grasses.

Young stock are successfully grazed from birth ahead of the dairy cows with benefit to themselves and no apparent harm to swards.

Milk from Grass—The New Zealand Dairy Industry *by M. M. Cooper* (*Prof. of Agriculture, King's College, Durham*).

One can say that virtually 95% of the nutriment required by dairy cattle in New Zealand comes from grassland. Except for a small proportion of town milk supply herds, concentrate feeding is negligible, because it does not pay. Forage crops have lost their former place as grass management techniques have improved, and marrow stem kale is now the only one of any consequence. With the low labour force on farms it does not pay to break good permanent pasture once it is established and with the sustained growing conditions, permanent grass gives very

high production over a long season. Yields of 500 gallons and more of Jersey milk per acre from such permanent grass are by no means uncommon, while yields per cow compare quite favourably with those obtained in other countries where liberal concentrate feeding is adopted.

Nitrogenous fertilisers are very expensive and are not used to any appreciable extent. The need for them is much less than in Great Britain, for there is an active growth of clover for practically nine months of the year. The winters are sufficiently mild for it to be practicable to hold a proportion of the autumn flush *in situ* for feeding to newly calved cows in the early spring before active pasture growth commences.

Increasing reliance is being placed on silage now that machinery such as the buckrake or the forage harvester is available. Most silage is stored on the surface in ' buns ' or ' wedges ' built in the field where the material has been grown. The wastage with the methods adopted is very high by British standards, but New Zealanders, with their fortunate climate, can afford to be rather more prodigal with their food surpluses.

Rotational grazing with some fold grazing in the early spring is widespread. It has systematised the provision of suitable grazing and the saving of reserves, and in this respect alone is fully justified. Because farms are not used for tillage crops the small fields are no disability and so permanent subdivision fences can be put up.

Effects of Low-protein Supplements on the Yield and Composition of Milk from Grazing Dairy Cows, *by J. L. Corbett* (*Rowett Research Institute, Bucksburn, Aberdeenshire*).

Under conditions similar to those obtaining in the experiments described, supplementary feeding of dairy cows grazing good pasture—in fact a partial substitution of relatively costly feeds in place of grass—is unlikely to be economic. The returns have been no better than the equivalent of 1 gal. of milk from 30 lb. supplement. A high-energy supplement such as flaked maize may be of value in certain cases where SNF levels fall below the legal minimum.

The Seventh International Grassland Congress—a review, *by A. S. Foot* (*National Institute of Research on Dairying*) *and W. F. Raymond* (*Grassland Research Institute*).

Some 12 papers dealt with problems in plant introduction and plant breeding. The various techniques of herbage plant breeding—polycross, utilisation of heterosis, tetraploidy, etc.—and the interactions between strain and environment were described. Because yield may be so modified by environment, it may be that further breeding for yield may be less important than breeding for other agronomic characters. The full exploitation of the extensive plant breeding now being carried out requires international standardisation of terms and techniques of testing, the latter having lagged far behind breeding programmes.

Pasture problems in difficult, especially in arid environments, were discussed in several papers. It seems that many of the criteria of good temperate grasslands, e.g. soil fertility, good management, need for legumes etc., apply equally in these environments.

Pasture productivity was related to several aspects of mineral nutrition, including soil/plant relationships, as well as to the effects of the grazing animal and nitrogen manuring, and the importance of conservation as one aspect of management.

Various more fundamental physiological problems, including responses of plant growth to light and temperature, and in particular the effects of defoliation on regrowth, were also considered. Much discussion took place on the relative effect of ' grazing method ' and ' stocking rate ' on the efficiency of grazing.

Three papers dealt with various aspects of molybdenum, copper, sulphate relationships in the plant and animal. Some data on animal production from grass and legumes in tropical and sub-tropical countries were also presented.

Grassland Management in Northern France. *by M. Andre Voisin* (*Farmer, Normandy*).

All grazing systems — rotational grazing, strip grazing, rationed grazing, close folding etc.—have failed and will always fail as long as the ' time ' factor is neglected. A variable rest period of sufficient length should be allowed between successive grazings. This should vary according to season —shorter at the beginning of the season than later on.

The rest period should be long enough to (*a*) let the grass reach its ' blaze of growth ', and (*b*) provide the animal with a better-balanced diet.

As there is a right time when grass is ripe for cutting, so also there is a right time when grass is ready for grazing.

At the same time, the period of occupation of a paddock by the herd should not be too long (four to six days), so that the grass is not chewed off more than once during the same period of occupation.

If these principles are followed, the grass will be chewed off six or seven times a year instead of, say, 20 times in uncontrolled grazing, and there will be a great improvement in grass production.

Technical News

Articles in the June issue of other journals of the Leonard Hill Technical Group include the following:

Dairy Engineering.—' Floors for Dairies ' by W. J. Rutherford, ' Fuel Efficiency at Cricklewood ', ' Care and Maintenance of Electric Motors in the Dairy, Part 2 '.

Food Manufacture, which is a special issue on canning — ' Canning Pilchards in Cornwall ' by E. B. Dewberry, ' Canning Bread and Bakery Products ', ' Large-scale Milk Sterilisation ' by Norman Brampton, ' Imitation Cream ' by Dr. Hirchberg.

Atomics.—' Pressurised Water Reactors for World Markets ', ' Nuclear Energy—a Conference for Industry ' (OEEC Report), ' Denmark's Atomic Debut '.

Chemical & Process Engineering.—' Flow Measurement Using Electromagnetic Inductive Methods ', ' Heat Transfer in Spiral Heat Exchangers ', ' Review of Instruments, Electronics and Automation Exhibition '.

Electrodusting

N. G. Shreeve

Erratum : WORLD CROPS, 1957, 9, 205. Table 1, delete 'particle size' and insert 'distance of plate from nozzle' and change the figures immediately below to 2 metres, 4 metres and 6 metres.

NEW PUBLICATIONS

Rice Culture in Japan

By Takane Matsuo. Pp. 128, illustrated. Tokyo: Yokendo Ltd. 1955. U.S. $2 (postage $0.30 extra).

Although Japanese methods of paddy cultivation and breeding have been outstandingly successful, hitherto almost all the literature on the subject has been published in the Japanese language. The present book is therefore particularly welcome because it describes in English the history of rice culture in Japan, shows the wide range of climatic conditions under which the crop is grown and explains the techniques developed in different parts of the country to conform with local conditions.

Particular attention is directed to the use of fertilisers and home-made organic manures. The very heavy dressings of fertilisers which have been usual in Japan are apparently justified, but it is noteworthy that they are now being used with greater care and the authorities are giving more encouragement to production of home-made manures so that these may be used as the basic application with commercial fertilisers as a supplement.

The author gives an account of the methods used in Japanese paddy cultivation. The very great care taken in preparation of the nursery, selection of heavy seed, protection of the nursery and ultra-careful transplanting contrasts with the rather rough and ready procedure adopted in many countries. Presumably this excessive care is justified by results, but it can only apply where labour is cheap and plentiful. One wonders whether some of the methods described are particularly advantageous. A curious omission is that throughout the book no information is forthcoming on the nature, chemical or mechanical, of Japanese soils. One has always felt that paddy will grow on almost any soil provided that water supply is adequate, but it is surely probable that the high yields in Japan are in large measure due to favourable soil characteristics.

A chapter is devoted to breeding. In the early days of research new varieties were obtained by pure line selection and this method proved remarkably successful. It was found, however, that heavy manuring caused paddy to become increasingly susceptible to lodging and to damage by disease, difficulties which may not be overcome by pure line selection. This has led to greater concentration on breeding. In view of the very successful and pioneer research carried out on this subject, one had hoped to find a more complete account of these investigations.

In contrast with the rather brief account of rice breeding, the book concludes with a very interesting and complete life history of the rice plant, accompanied by a series of excellent photographs.

'Rice Culture in Japan' is a welcome addition to the literature on this plant. The interest of this book whets one's appetite for a fuller and more complete treatise in English on the Japanese rice industry.

D. H. GRIST

Soils and Soil Fertility

By Louis M. Thompson. Pp. 451, illustrated. London: McGraw-Hill Publishing Co. Ltd. 1957. 2nd edition. 49*s*.

'This book has been prepared for use as a text for an introductory course in soils for students of agriculture.' The author explains in the preface that the book has been designed to fit his particular system of teaching and that the student is 'expected to read the book from the beginning rather than skip around for assigned reading.' The author has succeeded in his aims and has even surpassed them, producing a volume which is not only admirable for teaching, but provides an excellent survey of soil science which should be valuable for the ecologist and the agronomist.

The early chapters are concerned with the physical properties of soils and with soil moisture relationships, the chemical composition of soils, soil formation and classification. There is a lucid chapter on the clay minerals which, despite its lucidity, does not become dogmatic, and here, as elsewhere in the book, points of dispute between authorities and gaps in the evidence are commented upon briefly and in such a way that the reader is not bullied into one party's views.

A large part of the book is devoted to chapters on nitrogen, phosphorus, potassium, minor nutrients, liming and the use of farmyard manure. In these chapters emphasis is placed on the soil as a medium for plant growth and on interactions between the plant and the soil. The book concludes with chapters on crop rotation and on soil erosion.

The role of micro-organisms in soil fertility is discussed briefly, perhaps rather too briefly, and in future editions a more expanded treatment of the role of organisms in soil structure and in plant nutrition would be very welcome. It would also be an improvement if the soil fauna received fuller discussion —there is an unfortunate tendency for soil scientists to forget that a soil is a complex ecosystem involving food chains and that the role of bacteria in this system is important but not exclusive. These criticisms are small, for the book as a whole is an excellent synthesis of soil science presented agreeably.

The book is well illustrated. Some of the diagrams are designed to explain very simple concepts and presumably represent relics from the time when the book was a set of lecture notes. The author has seldom been concerned to reproduce actual experimental results (*e.g.* for the loss of organic matter from the soil during arable periods in a rotation); instead generalised graphs are presented. The desirability of this is questionable, for while such treatment aims at clarity, it gives the student a false impression of the true nature of experimental data.

There is a special emphasis in the book on the soils of Iowa—but these local examples are used to illustrate points of general interest and in no sense does their presence imply provincialism in the outlook of the book as a whole.

J. L. HARPER

Mechanisation of Tropical Crops

By W. N. Bates. Pp. 410, illustrated. London: Temple Press Ltd. 1957. 45*s*.

The author has set himself an immense task in dealing with such a vast subject and it could not be expected to find in one book a very detailed account of the problems, complete and up-to-date specifications of all the machines, instructions on machinery maintenance, and similar, more specific items which are best dealt with in one of the specialised works already available. The book does, however, present a fair picture of the way in which mechanisation can contribute towards increasing agricultural production in the tropics. Since

the introduction of mechanical equipment will be largely determined by the climatic conditions, the topography, the soil type and the need for soil conservation, drainage and irrigation, these aspects are discussed in the first part of the book, the account being mainly confined to those portions of the tropics which are within the British Commonwealth. The problems of mechanisation and the types of equipment needed for land reclamation, seed bed preparation, earth moving, drainage, irrigation, spraying and dusting, transport and other tasks are dealt with in Part II. In each case the machinery which, in the author's very extensive experience, has proved suitable for the task in question is mentioned. Almost half the book is devoted to a study of the cultivation of individual crops, giving some information on their characteristics, on cultivation and harvesting methods and, where applicable, means of mechanising the various operations. Some attention is also given to questions of the technical training of operatives and maintenance staff, the keeping of records, costs, machinery management and maintenance, which are so important in overseas territories. This is thus a much needed book on a subject which is becoming increasingly important. It provides manufacturers with some basis for assessing the potential market and the types of equipment needed, and the agricultural machinery officer, estate manager, planter, advisory personnel etc., with some guidance on the way in which machinery can be applied to a given task.

E. HARRIS

Plant Protection Conference, 1956

The Proceedings of the Second International Conference held at Fernhurst Research Station, England, have now been published and include a full record of the discussions which took place and of the papers read. The book should provide a valuable work of reference for all concerned with crop protection. The Conference was attended by eminent scientists from all over the world and among fundamental aspects of crop protection considered were the safe use of chemicals in agriculture, not only from the point of view of the worker applying them, but also the safety of the consumer of the crops which have been treated with chemicals; the achievements of the geneticists in relation to the breeding of crop varieties resistant to disease and their bearing on other methods of disease control; the mechanisms of toxicity; and the role of systemic chemicals.

Published by Butterworths Scientific Publications, price 50*s*.

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R.A.S.E.

The *Journal of the Royal Agricultural Society of England*, Vol. 117, includes articles on 'Management and Good Farming', 'The Role of Grass in Feeding the Dairy Herd', 'Temperature Requirements of Horticultural Crops', 'Research on Viruses and Virus Diseases', 'Crops and Plant Breeding', 'Soils and Fertilisers' and 'Farm Implements and Machinery'. There is also a supplement devoted to the 1956 Royal Show, including an awards list.

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O.E.E.C.

'Selection, Use and Maintenance of Agricultural Machinery' is the title of a useful new publication of the European Productivity Agency. As is pointed out in the foreword, 'the judicious selection, proper use and maintenance of suitable farm machinery is a major factor in increasing agricultural productivity'. As part of a threefold project concerning farm machinery an International Training Course was held in Sweden in November 1955 with the object of improving the methods for teaching and training farmers, agricultural engineers and advisers in this field. This publication contains the papers read by the guest speakers and a summary of the conclusions reached by the participants.

Price 8*s*., $1.25 or 400 F. fr.

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Weed Control

'The Weed Control Handbook, 1957', although based on the 1956 edition, has been considerably revised and enlarged. It is a comprehensive guide to the use of chemicals for the control of undesirable vegetation and is intended for all interested in the practical and technical aspects of this subject. There are chapters on the use of selective weedkillers in different crops, special weed problems, the non-selective use and the methods of application of herbicides and among the new sections included in this edition is one on the legal aspects of the problem of weeds and the use of herbicides.

Issued by the British Weed Control Council, price 5*s*. post free.

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Pea Growing

We have received the Report for 1955 of the Home Grown Threshed Peas Joint Committee. This is a review of all aspects of threshed pea growing for 1955 and includes a progress report on field experiments carried out on dates of sowing, seed inoculation and disease, weed and pest control. The publication will be of interest to all engaged in pea growing and may be obtained free of charge from the Pea Research Station, Yaxley, Peterborough.

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Other Publications

We have received copies of the following publications:

Plant Protection Guide to Pests and Diseases of Glasshouse and Market Garden Crops, a guide in easy reference form on how to deal with pests and diseases using the latest Plant Protection products.

The Standardised Disinfectants Co. Ltd. brochures in English, French, Portuguese and Spanish giving an account of the company, its history, products and services for importing countries.

Cinzas das Semeas de Arroz (Rice Bran Ashes), containing a description of the results of chemical study on bran ashes carried out in Portugal, with a summary in English. This may be obtained from the Comissão Reguladora do Comércio de Arroz, Rua da Madalena, 179, 2°, Lisbon.

Twenty-fifth Annual Report of the Minister for Agriculture, Republic of Ireland, 1955–56, price 7*s*. 6*d*.

Developments in Aircraft for Agriculture, a booklet produced by Auster Aircraft Ltd., surveys the role of aircraft today in agricultural operations, with special reference to the 'Agricola' (see WORLD CROPS, 1957, **9**, 83). Price 5*s*.

Annual Report for 1956 *of the East Africa High Commission*, restyled and illustrated, which includes a short review of agricultural forestry and fisheries research carried out during the year. H.M.S.O. Colonial No. 331, price 5*s*.

MACHINERY AND EQUIPMENT

The Whitlock goose-neck sugar-cane trailer fitted with rubber-faced steel tracks for use over exceptionally boggy or rough ground

Sugar-cane Trailers

Whitlock Bros. offer two sugar-cane trailers, the design of which is based on information collected at first hand in sugar-cane-growing countries.

Their four-wheel cane trailer has a floor size of 12 ft. × 6 ft. and the depth of the sides is 5 ft. When fitted with 9.00 × 16 stud wheel equipment and 2¼-in. square axles of 58-in. track, the trailer has a load capacity of 17,000 lb. The chassis has a 4-in. × 2-in. channel iron chassis and a full-locking 4-in. × 2-in. channel forecarriage, which, mounted with a turning ring of 3ft. 6in. diameter, gives maximum strength and stability. The sides of the trailer are constructed of 3-in. × 2-in. angle iron and the floor with 1-in. timbers, with steel cappings. A massive rear hitch is fitted as standard and an optional extra of steel sheets can be supplied for closing the ends of the trailer.

Their two- or four-wheel convertible goose-neck cane trailer has a body length of 10 ft. The width of the body is 4 ft. 7 in. at the floor and 6 ft. 10 in. at the top. The depth of the sides is 5 ft. 4 in. When mounted on 11.25 × 28 tyres on 3-in. square axles at the goose-neck it has a load capacity of 14,000 lb. of sugar-cane. The swivel pivot suspension at the front of the goose-neck can be replaced by a large ball joint and the rear hitch by a special socket box, which then enables one front axle and drawbar to be used with a train of trailers and reduces considerably the length of the train. Jacks are then provided at the front corners of the cane carts to facilitate coupling and uncoupling. As an alternative to the goose-neck, this model can also be fitted with the flat drawbar type with slightly lower sides. For use over exceptionally boggy ground there is an alternative undergear of 4-ft. × 13-in. rubber-faced steel tracks.

Reader Service

For further information on any item of machinery or equipment reviewed in this section please write to:

Reader Service,
WORLD CROPS,
Stratford House,
Eden Street, London N.W.1,
England

A New Low-cost Rotary Tiller

A new tiller featuring use of ' Select-O-Width ' tines has been announced by the Bolens Products Division of the Food Machinery and Chemical Corporation. ' Select-O-Width ' tines permit varying tilling swathe to row widths from 12 to 36 in.; extra tines slip on quickly and require only a steel pin to lock them in place.

Balanced for easy handling, the Model 61 ' Junior Mustang ' can be operated with or without optional wheels. The automotive cone-type clutch eliminates belts.

Power for the ' Junior Mustang ' rotary tiller is provided by a 2.25-h.p. Briggs and Stratton petrol engine, equipped with a rope starter. The 12 unbreakable hoe-type tines, provided as standard equipment, give a 12-in. tilling width.

The clutch and throttle controls are conveniently placed between the handles of the ' Junior Mustang ' rotary tiller

The Value of Compost

Many farmers and horticulturists believe that land requires natural humus to be put back into it in order to maintain and increase its fertility. Farmyard manure was once available to most farmers at an economic price and was widely used. Nowadays, with fewer horses, the supply is short and the cost is high, but so, too, is the cost of the artificial fertilisers, which are being used today instead of compost or manure. But for the shortage and high cost of labour much more compost would probably now be made.

The Standen-Hawkomatic compost mixer saves labour and ensures a strict uniformity of mixture

The ' Standen-Hawkomatic ' compost mixer removes this labour problem and would be of undoubted advantage to the farmer who, for instance, wishes to make compost with the straw left behind by the combine-harvester instead of burning it; to the horticulturist who is prevented from making full use of his waste vegetation because of the time and labour needed to turn it into compost; and to the nurseryman and mushroom grower, who usually require a very carefully prepared compost, which it is tedious to mix and turn by hand.

The machine consists of a revolving drum into which, on the first turn, the dry material to be composted is fed. With a controllable supply of water the material, as it passes through the drum, is thoroughly soaked. Wetting plays a very important part in the preparation of a good compost and this is done very efficiently by this machine. As the wetted material passes out from the drum and on to the stacking elevator, chemicals can be fed into it from a hopper, mounted immediately behind the drum. The rate of feed of

the chemicals is adjustable from 7 lb. to 4 cwt. per ton of raw material. The chemicals are immediately damped down by a fine spray of water. The mixture then passes up the elevator, at the top of which there is a spinner mechanism, which further breaks up, bruises and aerates the material. From the spinner the material is thrown on to the stack, which can be built up to a height of 6 ft. If required, the mixture can be put through the machine a second and third time at varying intervals, adding such additional water and chemicals as may be considered necessary to produce the type of compost required.

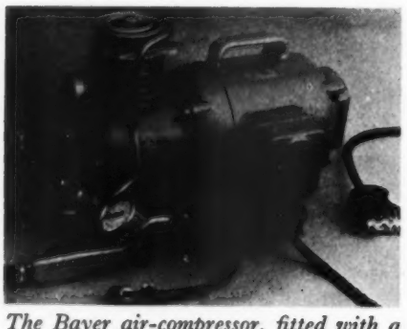
Compressed Air

The new Bayer air compressor provides the answer to some of the problems of the farmer. It can be used to inflate motor cycle, car, lorry and tractor tyres; for all types of paint spraying, limewashing and creosoting; for the application of chemical sprays for the protection of crops, cattle and farm buildings; and for fine-oil lubrication under pressure.

This air compressor can be attached to the p.t.-o. of the tractor, or it can be operated by an electric motor. It is capable of standing up to 600 r.p.m. It is said to be capable of giving up to 150 lb./sq. in., and 3 cu. ft./min. It is supplied with 15 ft. of oil-proof air tubing, fitted with a tyre inflator nipple.

The compressor is solidly constructed with perlite crankpins, oil bath lubrication, double cooling fin on cylinder head, and a heat resistant silicone rubber pressure valve, ensuring trouble-free and long service.

It can be supplied with ' V ' pulley, ' V ' belt drive and bracket for operation as a stationary unit with a 220/380-v motor and with other extras such as a refrigeration device, a hand spray gun or a portable knapsack sprayer, fitted with a 3-gal. container, 6 ft. of hose, a trigger lance, and an unchokeable nozzle.



The Bayer air-compressor, fitted with a 220/380-v motor. There is also a model which can be attached to the p.t.-o. of a tractor

The fully-automatic ' Marbeet ' harvester delivering cleaned beets from the collecting cart by conveyor into a waiting lorry

Beet Harvesting

In actual field tests the new ' Marbeet ' harvester has proved conclusively that it can lift all the beets in a field, both large and small, even under wet and adverse conditions which might stall many machines. Under favourable conditions one man and a ' Marbeet ' can harvest up to 100 tons of clean beets from 3 to 5 acres in a day.

The machine, which is fully automatic, is adaptable to most row spacings, including wide and narrow double-row spacing, and it performs well in a variety of soil conditions. Its coulters are adjustable for depth and also laterally, so that the ground on either side of the line of beets is cut. The loosening ploughs which follow dig under each beet in turn and lift it up until it is impaled on the spikes of the pick-up wheel. These plough shares are adjustable for different sizes of beets and also for varying soil conditions.

The pick-up wheel, with four rows of closely-spaced spikes, impales the beet by its crown and carries it round to the topping disks. Two sharp, rotating disks automatically top the beets as the pick-up wheel brings each in turn into position. Crowns and foliage are whisked away to a high-speed belt conveyor, which tosses them well clear of the tractor wheels. Thus they are preserved in good condition and can be used as feed for livestock.

The cutting action of the coulters and the loosening action of the plough shares remove most of the adhering soil. Then, after leaving the topping disks, the beets are scrubbed, tumbled and shunted by a spiral auger on to a chain belt. The final cleaning action is in the tumbling and bouncing along the moving flights of the chain belt conveyor system, which delivers the roots to the waiting lorry or beet wagon. This continuous cleaning action ensures that 95% of the beets are delivered clean.

Mechanical Thinning

Singling and weeding, especially in the cultivation of root crops, has always been a problem. Even with staggered sowing it frequently happens that the plants are all ready for thinning at the same time. Delay affects the final yield and hoeing by hand involves a large and costly labour force. The disadvantage of mechanical procedures, such as cross-blocking or gapping, is that large bunches of plants are left which still require a considerable amount of hand singling.

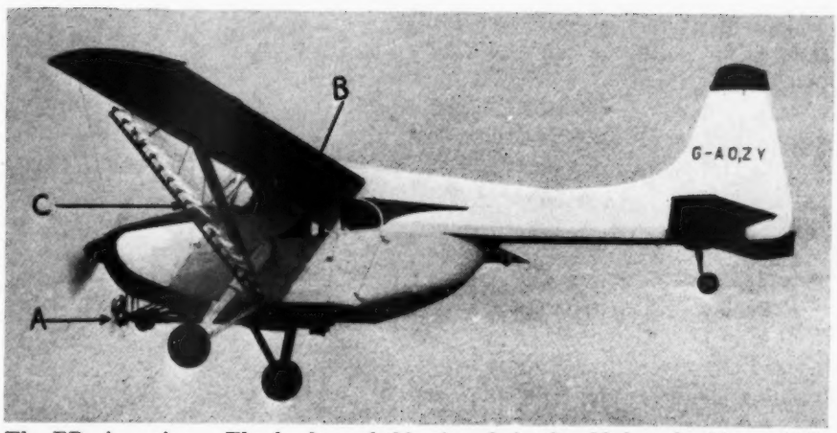
The Hudson down-the-row thinner can be used on any crop where a regular spacing of 10 in. is necessary, such as sugar-beet, fodder beet, mangolds, swedes and kale, and its use reduces hand labour to an absolute minimum.

Although excellent results can be obtained using natural seed and a standard drill, to achieve results that

will require little or no final hand work the use of rubbed seed and precision drilling is recommended, especially with sugar-beet. Machine thinning should begin as soon as the row is clearly visible. If for any reason the plants have grown beyond the normal stage, thinning can still take place, thus saving many crops which, under the old method of hand-thinning, would be wasted. An average emergence usually requires two thinning operations. Sample counts should be taken of the number of plants in a given length of row and, from the average obtained, the size of the tines which should be used and the number of operations that will be required can be reckoned from a chart. The second operation, if necessary, takes place as soon as the plants straighten up, usually two to three days later. A 16-tine head is used for the second operation and an eight-tine head is used first if there is to be more than one operation. The machine can be operated at speeds to cover three to four acres per hour and models are available to suit all small or large tractors fitted with hydraulic linkage.

A special tool that can be fitted to the machine is the spring tine head. This gives light in-the-row cultivation and removes weeds and poorly rooted plants in the early stages of growth.

In offering this machine to the public the manufacturers acknowledge the advice and assistance of the National Institute of Agricultural Engineering and the British Sugar Corporation.



The EP9 in action. The fuselage of this aircraft is of welded steel tubing, which, it is claimed, overcomes the corrosive effect of fertilisers or sprays. A—wind-driven pump; B—filler cap for spray liquids; C—nozzle-fitted booms

(Below) *An EP9 in service with the Manawatu Aerial Top-dressing Co., of New Zealand. The aircraft can carry one ton of fertiliser or seed on each trip*

Flying Jeep

The Edgar Percival EP9 aircraft (see WORLD CROPS, 1956, **8**, 455) is the first British agricultural aircraft to be sold to Germany.

The operational versatility of the aircraft has been increased and it is now fitted with liquid spray equipment. The German firm will use it mainly for spraying fruit crops. One of their main requirements was for a very high gallonage of liquid to be sprayed on each run and the EP9 has an extremely efficient performance in this respect; it sprays a swath width of 90 ft. at a speed of 100 m.p.h. This width of swath, coupled with the higher operating speed, accounts for the high acreage per hour covered by the machine.

The spray tank fitted to the aircraft holds 170 gal. of liquid and it has a pump with a capacity of up to 150 gal./min. Its normal running rate is equivalent to 20 gal. of liquid per acre. The wind-driven pumping unit is by Fred W. Pickell and Associates and the boom is fitted with ' TeeJet ' spray nozzles (manufactured by Spraying Systems Co.).

Although primarily designed for agricultural work, the EP9 can be used in a number of alternative roles, including that of a feeder line aircraft, when it is a six-seater with full luggage. The aircraft is also suitable for survey work, aerial photography and for flying ambulance duties. In the latter role it can carry two stretcher cases, a walking case and an attendant.

The EP9 can also be used for dropping supplies and has a useful load

The Hudson thinner at work with eight-tine heads for the first operation. Alternate small cuts are made, leaving equal spaces along the row. This leaves half the plant population

of a ton with full luggage. Even when fully loaded it can take off and land in restricted areas. It touches down at only 37 m.p.h. and takes off in 105 yd. with full normal load and in 165 yd. with the agricultural overload. Floats or skis are optional in place of the conventional undercarriage.

Principal characteristics

Power plant. Lycoming GO-480 B, six - cylinder, horizontally - opposed. Take-off power, 270 b.h.p. at 3,400 r.p.m., 1.2 lb./sq. in. Rated power, 260 b.h.p. at 3,000 r.p.m., 1.2 lb./sq. in.

Plane dimensions. Span, 43 ft. 6 in.; length, 29 ft. 6 in.; height, 8 ft. 9 in.; wing area, 227.6 sq. ft.

Landing gear. Track, 10 ft. 10 in. Maximum vertical velocity, 9 ft./sec.

Weights. Weight unladen, 1,950 lb. Useful load, 2,190 lb. Gross weight, 4,140 lb.

Performance. Maximum speed: take-off power, 146 m.p.h.; maximum continuous, 142 m.p.h. Cruise: maximum, 128 m.p.h.; economical, 120 m.p.h. Initial climb, 1,120 ft./min. Ceiling, 17,000 ft. Still-air range, 585 miles. Maximum endurance, 5 hours. Landing speed, 37 m.p.h. Take-off run, 5-m.p.h. wind: unstick, 315 ft.; to 50 ft., 675 ft.

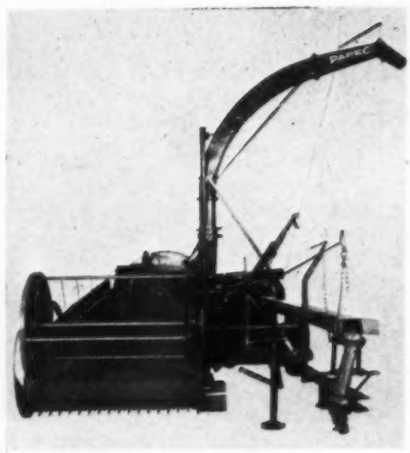
New Nut Grader

A new electrically powered nut-grading battery, called the ' Polygrada ', has been developed by the machinery manufacturing division of a London wholesale seed merchant.

A typical battery is made up of four units—one diameter grader and three length graders—that can sort groundnuts, or other nuts and beans of similar size and shape, at a rate of 500 lb. an hour. Each grader can be used independently, if required.

The ' Polygrada ' is said to be the only one of its kind in the world that can mechanically and economically grade nuts and beans by length and/or diameter. It is claimed, too, that it will not damage the nuts or cause kernels to split. Only one operator, who can be trained very quickly, is needed to work it.

The four-unit battery works on the following principle: the nuts or beans are hopper fed into the diameter grader, which, by means of special vibrators, sorts them into three main grades—large, medium and small. In addition, it will grade out splits. The nuts are then fed automatically through a hopper to the length graders, which sort out each grade into long or short sizes.



The Papec No. 32A forage harvester with direct cut attachment

Improved Forage Harvester

The new Papec ' 32A ' forage harvester, manufactured by the Papec Machine Co., incorporates several improvements on the Papec ' 32 ', which has already given outstanding performance on all forage crops during the past year. These are improved feed roll drive, increased belt take-up, reinforced frame, improved shift lever, improved sickle drive on direct-cut and row-crop attachments.

In addition, the new ' 32A ' has adjustable axles, patented silage shelf, side and rear feed delivery, automatic delivery pipe control, adjustable hay pick-up fingers and straight, easy-to-sharpen knives.

A New Pump Seal

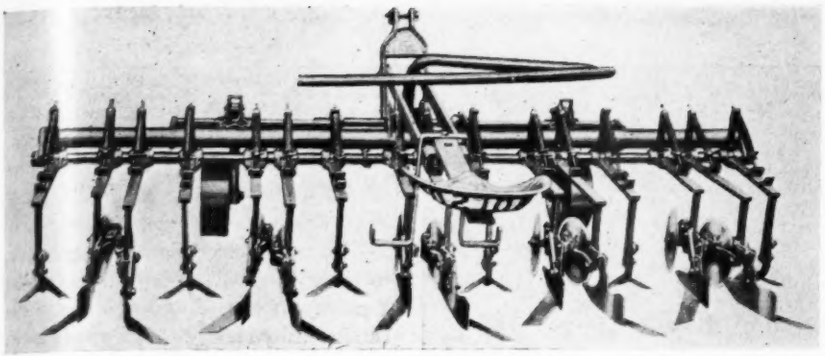
Details have been received of the seal now incorporated in the redesigned Alcon pump (WORLD CROPS, 1957, 9, 127). The Crane Type 109 mechanical shaft seal was the first flexible mechanical shaft seal, manufactured in the U.K., capable of being used to seal against corrosive liquids and gases at temperatures up to 450° F. and pressures of up to 200 lb./sq. in. The corrosion-resistant materials formerly used to give the flexibility required were normally made of rubber or rubber-like composition. In the new seal the flexible member is a wedge ring manufactured from the new plastic material, polytetrafluoroethlene, which is located behind the carbon seal ring.

The new seal is designed for incorporation in centrifugal pumps, turbines, displacement pumps, agitators etc. in which corrosive liquids and gases are being handled.

Steerage Hoe

The steerage hoe, type BTO8, manufactured by Nicholsons, can be mounted on any tractor having standard three-point linkage, with stabiliser bars, or links, fitted to the two

' Polygrada ' nut grader sorting nuts for length



The seat of the BTO8 steerage hoe is conveniently placed to give a clear view of the plant rows

bottom arms; lifting pins are constructed so that the hoe can be changed over from one tractor to another of a different make without trouble. The steering is on a new principle, which is very light and is said to be free from the influence of the pull or steering of the tractor and from the overrun due to swivelling steering wheels.

The working depth of each disk can be set in relation to the following blade. The disks are reversible for earthing up and can be adjusted from parallel with the row to an angle of 25° from it; each disk is mounted on a swivelling vertical stem provided with serrated quadrant and washer adjustment. The pitch of the hoe blades and 'A'-shares can be easily adjusted and the 'A'-shares hooked up out of work by simple built-in means without even the use of a spanner.

This hoe is available either as a four- or five-row model for building rows up to 22 in.

Knapsack Container

Cooper, Pegler & Co. Ltd. have just introduced a knapsack container, holding 2 gal., for use with their 'Hydra' sprayer. This enables spraying to be quickly and easily carried out, without having to stop from time to time to move the bucket containing the spray. It will be of interest to the smallholder, market gardener, and small fruit grower and for garden use and research work generally.

The single adjustable plastic strap enables it to be carried on one shoulder or bandolier fashion. The container, which weighs approximately 4½ lb., is cylindrical and is internally coated with a special material, giving complete protection against all the various chemicals, washes, etc., which can be used with the 'Hydra'. The top cover has a 2-in. filling hole with a screw cap, through which the suction hose passes. A Grommet in the cap prevents any liquid splashing out when the container is in use. The whole cover can be removed enabling the inside of the tank to be easily cleaned.

The Pye master pH meter, No. 11068

New pH Meters

The whole range of Pye pH equipment has been revised and the company has branched out in several other directions, including conductivity and chromatography.

Many refinements have been built into the new Pye Master pH meter to provide the utmost stability, accuracy, and convenience in use. It is a direct-reading, mains-operated instrument, incorporating the following advantages :

(1) The effective scale from pH 0—14 is 11 in. long.

(2) The scale overlap is 6 pH units. This permits titrations to be made over a wide range of pH change without any need to alter the range switch.

(3) Full automatic temperature compensation is provided; the instrument can be buffered at one temperature and readings made at any other.

(4) Measurements can be made in either earthed or unearthed solutions.

(5) The very wide buffer range allows almost any type of electrode assembly to be used with the instrument.

There is also a simple general purpose instrument, pH meter, No. 11070. This new instrument has but one control and thus provides the simplest possible operational arrangement.

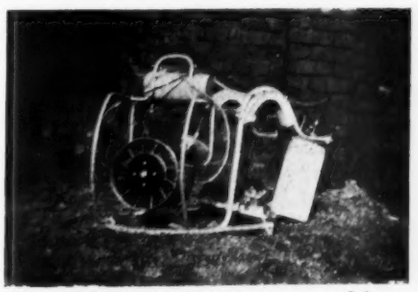
It is mains-operated and direct-reading on a 5 in. scale, which covers the whole 0—14 pH range. Zero stability for a 10% change in mains voltage is better than ± 0.05 pH, between the limits of 180 and 270 v. Temperature compensation is effected automatically by means of a platinum resistance thermometer in the electrode system. Particular care has been taken to ensure the utmost reliability and ease of maintenance.

The Micronette

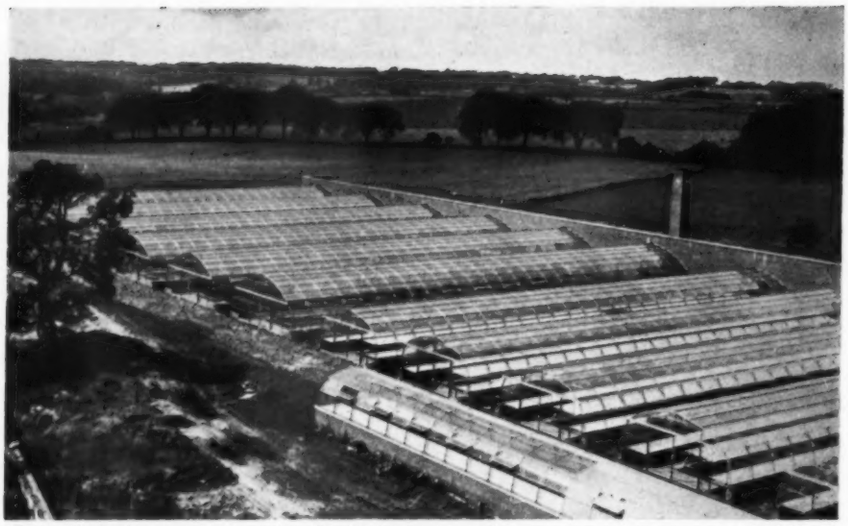
Export orders do not come to those who wait at home—the Chairman of Micron Sprayers Ltd. has left for the West Indies and Central America to introduce the new Micronette sprayer, an ultra-low-volume or concentrate sprayer, specially designed for spraying bananas, cocoa, coffee and tea with 3 gal. of spray liquid or less per acre.

This is a power-driven shoulder-mounted sprayer that weighs only 28 lb. and is carried on the back. It is claimed to be the lightest power-driven portable sprayer in the world, and it has only one moving part—the engine shaft. The whole basic unit may be dismantled for cleaning and maintenance in five minutes.

It is powered by a tiny 34 c.c. J.A.P. air-cooled 2-stroke engine and attached to the engine shaft there is an axial flow fan which produces 950 cu. ft. of air per min., and a Micron rotary atomiser, which is capable of



The 'Micronette' — a power-driven shoulder-mounted sprayer that weighs only 28 lb.



Part of the Leeds Corporation Parks Department's new central nursery at Red Hall, Shadwell, England. The glasshouses are constructed in stove-enamelled aluminium

producing an extremely fine and even droplet spectrum. Its broad spray beam eradicates the possibility of scorch on close foliage.

The spray liquid is carried in a plastic bottle which is carried in front of the operator, and which allows easy agitation and also allows the operator to keep a watch on the amount of liquid being sprayed. The bottle is lightly pressurised from the engine.

The Micronette is intended to be carried on the back in a new yoke type carrying frame which is much more comfortable than shoulder straps and allows the machine to be mounted very quickly. This yoke frame is made of light tubular steel, which can be easily welded if any breakage occurs. The machine can also be mounted on any form of traction vehicle and in this case the beam of spray can be manually directed.

Aluminium for Glasshouses

Stove - enamelled aluminium has been used in the construction of the glasshouses chosen by the Leeds Corporation Park Department, England, for their new nurseries.

Although aluminium is widely used unpainted for glasshouses, it was decided to stove-enamel the metal in this instance, since stove-enamelling supplements the inherent durability of the aluminium and affords extra protection against the injurious mercury and copper salts sometimes contained in insecticides. The glazing bars are made of Noral 50S alloy, supplied by Northern Aluminium Co. Ltd., and are designed to support an entirely new glazing system that uses a polyvinyl-chloride cushioning on all four edges of each pane of glass, thus making it shock-, draught- and waterproof. The lightness and strength of the aluminium alloy enables the glazing bars, stanchions and other supports to be as narrow and as few as possible, so that maximum light with few shadows and clear unrestricted working space may be obtained. Aluminium staging, easy to clean and wash down, is used in some of the glasshouses.

The intricate aluminium sections used for these glasshouses have been designed for strength, ease of glazing, minimum obstruction and maximum light admission, made possible by the extrusion process by which the aluminium is formed.

Aluminium is being applied successfully, in association with transparent plastic sheeting, in the construction of plant houses used for research on the role of trace elements in plant nutrition.

For the Handyman

It is claimed that Bridges' comb jointing attachment not only takes the drudgery out of corner jointing in case-making, but it also ensures a perfect fit. This is a new attachment for the Bridges' 'Toolpower' and other makes of saw benches up to 7 in. in dia. It produces, quickly and easily, angle or spliced joints in timber, plywood, hardboard or plastics. It will comb any width of material and no marking out is needed, as the joints are self-positioning.

A Precision Drill for Sugar Beet

The importance of accurate spacing in row planting was dealt with in a previous note, see WORLD CROPS, 1955, **7**, 172. Tests have proved that the Stanhay seed-spacing drill will ensure the required precision.

This is a spacing drill for attachment to the toolbar of a tractor through the 3-point linkage. A number of drills can be easily and quickly assembled on the toolbar to form a gang of drills, arranged at the desired interval for row spacing.

A single drill consists of a seed-monitoring unit carried on a sprung chassis, fitted with a coulter and carried on two flat wheels. The monitor consists of a seed hopper, a seed agitator, and an endless rubber belt, perforated with a succession of round holes at accurate intervals. This belt picks up seeds, one at a time, and delivers each in turn at the rear of the coulter. The coulter produces a small 'V' shaped furrow for the reception of the seeds as they fall from the monitor. The seeds are covered and the soil is consolidated by the spring-loaded rear wheel which also drives the monitoring unit.

Obviously the Stanhay drill will give a perfectly straight and parallel line of seedlings with no variation between the rows and also a uniform depth of planting at any pre-determined depth up to ½ in.; this adjustment for depth is simple and accurate. There will be complete accuracy of spacing with no clusters or gaps, as each seed is delivered individually and unfailingly at the same intervals. There is little likelihood of drift, due to draught, as the seed has only to drop 1 in. from the belt to the bottom of the furrow.

This precise method of planting naturally facilitates subsequent mechanical hoeing and placement of manures, and mechanical thinning can be carried out with safety because of the very even spacing and the even braird.

There is an illustration of the Stanhay spacing drill in action on page 230.

Artificial Rain

Erratum: WORLD CROPS, 1957, 9, 217 col. 3. '51 minutes' should read '15 minutes'.

Agricultural Chemicals

Plant-growth stimulator: fungicide & nematocide: insecticide: herbicide: seed dressing: combined fertiliser & weedkiller

Growth Stimulation

Pfizer Ltd. are offering small quantities of gibberellic acid to research workers interested in plant-growth stimulators. The product is obtained by fermentation processes.

Experimental evidence so far available in the U.S.A. indicates that gibberellic acid, when sprayed on plants or trees, can result in a doubling or trebling of linear growth in a few weeks. The effects are most spectacular with dwarf varieties, indicating an important association with genetic structure.

The growth-stimulating effects of gibberellic acid were first observed around 1926 by Japanese plant scientists. Notable pioneer work has since been done by Dr. S. H. Wittwer, of Michigan State University, and by Dr. W. P. Brian, of the Akers Research Laboratories in Welwyn. Currently, Rappaport, of the University of California, is investigating the effects of gibberellic acid on potatoes and tomatoes.

One variety of potato was, while dormant, treated with varying amounts (microgrammes) of gibberellic acid. These potatoes sprouted in four weeks. Sprouting of the untreated controls began five weeks later. In general, the greater the amount of gibberellic acid used, the earlier the sprouting.

Another variety of potatoes was dipped in water containing 25 p.p.m. of gibberellic acid, and of these 90% of the tubers were sprouting within a month, as against only 11% of the untreated controls.

When tomato plants were sprayed with gibberellic acid twice weekly the crop of fruit was significantly increased. The results were obtained with water containing from 1 p.p.m. to 500 p.p.m. of gibberellic acid. There was no noticeable difference in gain between the two limits.

*

Active Carbon

Active carbon is a very pure form of carbon which has an enormous internal surface area of the order of 10 acres in 1 oz. of carbon. This surface has been made 'active', *i.e.* its absorptive power has been considerably increased by a special high-temperature treatment.

Active carbon is offered by Sutcliffe, Speakman and Co. in several forms, according to the requirements of the job, and the manufacturers should be consulted regarding special applications and uses. It may be used for water purification, for decolorising and for deodorising. It is used in sugar refining, for recovering valuable solvents from the air and for clarifying spirits.

*

Experimental Farm

Union Carbide and Carbon Corporation has purchased a 142-acre farm in North Carolina, U.S.A., for experimental work on the newest Crag synthetic herbicides, fungicides, nematocides and insecticides.

Crag agricultural chemicals, of course, are already widely used. ' Crag Sesone ', formerly called ' Crag Herbicide-1 ', is being used to kill weeds in fields of groundnuts and strawberries and among flower and horticultural crops. ' Crag Glyodin ' is used to prevent apple scab, ' Crag Fly Repellent ' keeps livestock relatively fly-free, and ' Crag DCU ' is a weedkiller used widely in sugar-beet cultivation.

A fungicide and nematocide called ' Mylone ' is being tested for the control of the worst annoyances to horticulturists and market gardeners, *viz.* nematodes, certain weeds and several soil diseases. ' Mylone ' is applied to the soil before planting either as a water suspension or as dry powder; then it is thoroughly worked into the soil.

' Mylone ' was applied to the soil on the left before the turnips were planted. They have grown well without hindrance from weeds, nematodes or soil fungi. The turnips on the right were planted in untreated soil and are struggling for survival in a weed-choked row

One method for controlling nematodes and soil fungi is by the use of fumigants held in the soil with plastic covers; ' Mylone ' does not require plastic covers and is therefore more convenient to use.

*

Toxaphene Formulations

' Eston Estonox ' is a highly effective insecticidal formulation based on toxaphene and is available in two forms. ' Eston Estonox-40W ' is a wettable powder containing 40% of technical toxaphene for use in situations which favour the use of sprays in reasonably high-volume applications. ' Eston Estonox-60E ' is an emulsifiable solution containing 6 lb. toxaphene/gal., suitable for use in low- or high-volume spraying and all types of equipment, either ground or air. ' Eston Estonox-60E ' meets the most exacting requirements for dispersion, hard-water tolerance, stability in storage, and coverage.

These ' Estonox ' sprays will produce a better initial insecticide deposit and a longer residual deposit. They can be applied over a wider range of weather conditions, thus permitting better timing, they are economical and easy to use, and they are generally much less liable to drift than dusts, which lessens the danger of contamination of adjacent crops.

' Eston Estonox ' can be used for the control of boll worm, lygus, leaf worm, thrips, army worm, cotton aphid and boll weevil on cotton; of grasshoppers and insects on grasslands and alfalfa; of sugar-beet webworms; of pear psylla; of serpentine leaf miner on beans, potatoes and tomatoes; and of pests such as ticks, lice and horn-fly on livestock.

*

A New Herbicide for Brushwood

' Spontox ' is a brand of concentrated spray material based on low-volatility esters of 2:4-D and 2:4:5-T. It kills all the herbaceous weeds normally controlled by 2:4-D, as well as

bramble and many of the woody weeds known as brushwood (young birch, hazel, gorse and many others). Brushwood encroaching on uncultivated ground provides cover for pests, smothers indigenous grasses and adds to fire risks.

Herbaceous plants, such as bindweed, docks, ragwort, sorrel and thistles, also respond to treatment with ' Spontox '. Oak, ash, maple, beech, hawthorn and rhododendrons are fairly resistant, but can be controlled by special treatment.

Grasses are unharmed and form a natural and manageable cover once the brushwood has been removed.

The applications can be made in three ways:

Foliage spray.—This is the most effective method for small scrub, particularly brambles and briars. It should be carried out when the plants are in full leaf and growing vigorously. Brambles are much more susceptible at this stage than when newly shooting. Thorn hedges can be cleared of brambles without much risk, so long as the spray, probably from a knapsack sprayer, is directed as much as possible on to the bramble foliage.

Basal bark spray.—For the control of saplings up to 1½ in. in diameter and dense birchwood brush, where effective foliage spray is difficult, the requisite amount of ' Spontox ' is mixed with mineral oil (kerosene, vaporising, gas or diesel oil) and applied to cover the lower 3 ft. of the bark. Treatment can be applied individually or dense young scrub can be given a drenching spray. A single jet aids penetration of very dense growth. Absorption is assisted by frilling or slashing the larger growths before treatment.

Stump treatment.—Where hand cutting has been carried out, the stumps remaining can be killed with ' Spontox ', 1 pt. of which is mixed with 5 gal. of oil or water and painted or sprayed either on to the cut surface within a few days or over the whole stump and surroundings the following spring. This method is particularly effective with hardwood species of diameter greater than 1½ in. and for the control of gorse.

' Spontox ' can be used to clear rough grazing, but not pastureland, since it severely damages clover. It is harmless to man and animals in normal usage, but all the usual precautions against contamination of neighbouring crops, orchards and gardens, as well as seeds, fertilisers and implements, should be observed. It must not be allowed to run into streams or ditches watering trees or crops that are not to be treated. In windy weather the possibility of damage by spray drift must be taken into particular consideration.

*

100 Years of Progress

Sir John Bennet Lawes took out the first patent for the manufacture of superphosphates in 1841. It was in 1857 that the firm, then known as J. B. Lawes' Patent Manures, moved from Deptford to Creeksmouth at Barking, Essex. Today the small works of 100 years ago has grown into a large and complex manufacturing organisation which supplies the farmers of Britain with ever-increasing quantities of fertilisers.

*

Economical Seed Dressing

Farmers will save money by using ' Dieldrex B ' at lower dressing rates for the control of flea beetle. As a result of further large-scale field trials Shell Chemical Co. are now able to recommend a reduction in the normal dressing rate from ¾ oz. to ½ oz. per 1 lb. of seed, except where infestation is expected to be heavy.

' Dieldrex B ', introduced during 1956, was the first seed dressing containing dieldrin and thiram to be produced. Already it has proved successful on thousands of acres for the control of flea beetle in kale, cabbage, turnips, swedes, rape and other crops. It has also given excellent control of fly in carrots and parsley and the ravages of onion fly in onions. Soil-borne diseases, causing ' damping-off ' and ' foot-rot ', are also controlled, and it gives some protection against wireworm. Although early- and late-sown carrots are effectively protected by ' Dieldrex B ' against carrot fly, subsequent spraying with ' Dieldrex 15 ' may be required where a late attack is expected.

The advantages of ' Dieldrex B ' are its economy and convenience in use. It does not taint carrots or other crops. There is no adverse effect on germination, growth or quality of the crops. Rapid emergence facilitates early interrow cultivations and reduces weed competition. Also good adherence to the seed is obtained without the addition of a sticker.

*

A Combined Fertiliser and Weedkiller

Wild oats—one of the arable farmers' main weed problems, especially in Eastern England—can now be controlled in sugar-beet by a new combined fertiliser and weedkiller, 'Fisons 31 plus Tecane', which combines ' Fisons 31 ', the most widely used compound fertiliser, with Tecane, the successful new chemical control for wild oats.

At present the mixture is only recommended for the control of wild oats in the sugar-beet crop, where the absence of these weeds has the immediate benefit of simplifying and cheapening hoeing and singling, especially where down-the-row mechanical thinning is carried out. It should be applied to the seed bed 14 days before drilling the sugar-beet seed, at the rate of 9–12 cwt. per acre, and should be brought into close contact with the germinating wild oat seed. Its application should be followed by two or three seed bed cultivations to a depth of 5–6 in. to mix the chemical thoroughly with the soil.

Work to date has given an average of 77% kill of wild oats, with many results as high as 95%, according to soil type and locality. Of the wild oats surviving treatment, many will fail to reach the seeding stage and others will be removed by normal cultivations, thus reducing the wild oat population to the point where hand pulling can be used to eliminate all seeding of wild oats for that season.

Mushroom Insecticides

See: WORLD CROPS, 1957, 9, 132, col. 2. ' Basudin ' is an organo phosphorous insecticide which is produced by the Geigy Co. Ltd.

Reader Service

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WORLD CROP REPORTS

Sugar : rice : rubber : olives : pepper : mustard

INTERNATIONAL

Sugar-cane

Production of white sugar in *India* in the year November–October 1956–57 is estimated by *Indian Sugar* at 2,050,000 tons. This compares with out-turns in 1955–56 and 1954–55 of 1,860,545 tons and 1,589,732 tons respectively. Stocks at the end of the 1955–56 season are put at 542,400 tons, as against 432,000 tons brought in at the beginning of the programme. Consumption during 1955–56 amounted to 1,938,000 tons, which figure is expected to be exceeded this year by a further 75,000 tons.

Details of the second estimate of the current sugar-cane crop are as follows:

	Area, acres	*Cane production, tons*
1956–57 ..	4,532,000*	58,914,000*
1955–56 ..	4,446,000†	57,749,000†
1954–55 ..	3,994,000	56,923,000

Sugar production during the current season 1956–57 is expected to amount to 60,000 tons in *West Pakistan* and 50,000 tons in *East Pakistan*. Against this, consumption in West Pakistan, including the administration in Karachi and the Pakistan army, is about 135,000 tons, whilst it is estimated at 55,000 for East Pakistan, a total of 190,000 tons. This means that the latter is now practically self-supporting for sugar.

Despite the bad climatic conditions experienced last season in the *Argentine*, the sugar crop exceeded all expectations, production finally closing at 724,000 long tons. Although it is too early as yet to make any forecast of the 1957–58 crop, early development has been favourable and more copious rains have been received than during the corresponding stages of growth last season.

In *South Africa* the 1956–57 season has come to an end with a final production of 848,645 short (757,719 long) tons, a reduction of 80,656 long tons from the previous season's record output. This decline was attributed partly to a drop in the cane harvest, which was, at 7,533,372 short (6,726,225 long) tons, 421,980 long tons less than in the previous year, and partly to the lower sucrose content. The average yield for the season was 13.35%, against 13.87% in 1955–56, and the ratio of cane per ton of sugar was 8.87 tons, compared with 8.51 tons in the previous season. A very provisional estimate gives a total of 883,000 short (788,393 long) tons for the coming crop. Weather reports indicate that the new crop has enjoyed one of the best growing seasons in memory; cane is making excellent progress and from most sources there is evidence of the prospect of a bumper cane crop. In the 1957–58 season consumption is expected for the first time to exceed the 700,000 short (625,000 long) tons level.

*Second estimate. †Final estimate.

According to the latest estimate of the Sugar Association of the *Philippines*, the 1956–57 sugar crop will amount to about 1,081,000 long tons.

Hopes are being expressed that 1957 will be a better year than 1956 for *Mexican* sugar. It is widely believed that the measures taken by the Government after the disastrous effects of the cold weather in January 1956 have been successful and that this year's crop will be ample for local consumption and leave a margin for export.

The prospects for 1957 in *Cuba* are excellent. Following the International Sugar Conference, the President of the Republic announced that the crop for 1957 would be 5,150,000 tons, or 550,000 tons more than last year. There was also a feeling of optimism that the 1957 prices would be higher than those of 1956. However, it is understood that there is now no longer any limit on the tonnage of cane which could be crushed. This would seem to indicate some anxiety that the total cane available may fall short of the equivalent of the decreed sugar tonnage. Yields, both as to sucrose and cane tonnage, vary considerably throughout the island.

Rice

Favourable growing conditions for *Burma's* 1956–57 rice crop have resulted in an excellent harvest. The crop, estimated at 7,100,000 metric tons of rough rice (15,680 million lb.), is the largest since the war.

The surplus available for export in 1957 is estimated at two million metric tons in terms of milled rice. This is approximately the same as the post-war record exports of 1956. The bulk of the 1957 exports, however, will be from the current crop, whereas 1956 exports were supplied from the 1955–56 crop, plus heavy carry-over stocks at the beginning of the year.

Thailand's rice crop of 1956, harvested principally in December, was possibly the largest on record. At least 1,500,000 metric tons are expected to be available for export during 1957, according to the Ministry of Agriculture. All rice for export this year will be from the new harvest, since stocks from previous crops were virtually depleted at the end of 1956.

Only in 1951, when rice exports from Thailand were 1,555,000 metric tons, have exports previously reached the total indicated for 1957. Rice exports in 1954 and 1955 were down to around 1,200,000 tons. Preliminary statistics give exports in 1956 as around 1,250,000 tons and subsequent data may give a slightly higher figure.

The 1956 rice crop of *El Salvador*, harvested mainly from October to December, is estimated at 55 million lb. of rough rice, the smallest figure in several years. Production in 1955 was reported at 65 million lb., a decline from around 75 million lb. in both 1953 and 1954. The reduction in output this season is due principally to a slight decline in acreage and unfavourable weather in several important producing areas.

Rice imports will be needed in the next six months, though the actual quantities are not yet known. Rice imports in 1955 were 12,975,000 lb., and in the January–June period of 1956 about 9,935,000 lb. Though statistics are not yet available for the last half of the year, imports since July 1956 are reported to have been small.

It is predicted that the current rice crop in *Costa Rica* will prove to be the largest in the country's history. According to figures published by the National Production Council, purchases by the Council in the leading rice-producing areas of the country as at 30 September were approximately 30% higher than purchases at the same time a year earlier. The crop is ex-

pected to yield 467,000 quintals.

Italy has 138,138 ha. under rice this year, according to the latest estimate published by the official Central Institute of Statistics in Rome. This represents a decrease of 18% on last year. Rice production is estimated at 648,300 metric tons—26.3% below the 1956 total.

Rubber

Sir John Hay, chairman of the Guthrie Group of companies which owns large rubber plantations in Malaya, reviewing the prospects of the natural rubber industry in relation to competition from synthetic rubber, says that the future is hopeful. While recognising the hazards of forecasting the production and consumption of rubber, he suggested that during 1957 the production and consumption figures would each be approximately 1,900,000 tons. During 1955 and 1956 world purchase of natural rubber reached a peak total of 3,795,000 tons. Of that amount, 1,198,000 tons were taken by the U.S.A., a significant fact in view of the readily available supplies of synthetic rubber.

BRAZIL

Production of *pepper* as a commercial crop began in Brazil about 1948. The progress during the past decade is mainly attributable to the presence of a potential export market. High domestic prices, brought about by import exchange controls and a sure market for at least 1,000 tons of black pepper, also helped the early expansion of the crop.

The Ministry of Agriculture in Brazil has made a preliminary estimate of pepper production for 1956 of 1,368 metric tons. Other sources have estimated the production for Para alone at 1,500 tons and are forecasting a crop of about 2,300 tons for 1957. If this production is realised, Brazil will probably be in a position to export 1,000 tons or more.

Para is the principal state producing black pepper, accounting for about 92% of the total. The harvest season extends from August to December.

CANADA

The Canadian Department of Agriculture states that the growing of commercial *mustard* began in southern Alberta about 25 years ago, and in the last decade it has become an important dry land crop. Before 1956 Alberta's mustard acreage varied from 30,000 to 60,000 acres, but last season Alberta farmers planted an all-time record of 138,000 acres. This was due chiefly to increased demand in Japan.

The yellow variety was in greater demand than the brown or Oriental, but because the requirement from Japan last season was for the Oriental variety it was sown on two-thirds of the total acreage.

The production and marketing of mustard is a specialised business. A high proportion of the crop is marketed in foreign countries and the number of buyers is limited. For this reason almost all of Alberta's mustard is grown under contract. The total acreage contracted is based on what the market is likely to absorb. When abnormally high yields are obtained a mustard surplus can result in a reduced acreage the following year.

EUROPE

The severe winter of 1956 has caused serious damage to the *olive* trees of France, Spain, Portugal and Italy.

In Italy, out of a national stock of about 160 million olive trees, 20% have been severely damaged. In Umbria alone some 900,000 dead trees have to be replaced and nearly four and a half million trees have to be stumped to strengthen the stem shoots. The olive trees regrown from two, three or four stump shoots will take eight to 10 years to bear fruit. The total loss in Italian production, calculating a minimum of 1 kg. of oil per tree, and allowing for the two million dead trees, the six million topped and the 12 million stumped, may be estimated at 160,000 quintals per year for 10 years.

In France, also, the 1956 frosts were a national catastrophe. The damage took the form of wholesale destruction in 10 out of 12 olive-growing regions, leaving one million absolutely dead trees, three million to be regenerated by cutting back, and two million to be pruned back to the main branches. Spain and Portugal also suffered severely.

UNITED KINGDOM

This season's sugar-beet harvest in Britain exceeded 5 million tons, the British Sugar Corporation announces. This was 600,000 tons better than the previous year.

ENGLAND AND WALES

Agricultural conditions in England and Wales on 1 April, 1957, have been summarised by the Ministry of Agriculture, Fisheries and Food.

Except on some lighter soils, wet condition of the land delayed cultivation and sowing. Autumn-sown cereals are generally satisfactory, although waterlogging has caused some loss of colour.

Weather conditions

The weather during March was exceptionally mild and rather dull. Rain fell frequently in most areas and falls were above normal for the month in Wales and in south-western areas of England. Some light ground frosts occurred.

Autumn-sown crops

Autumn-sown *wheat* is generally healthy and forward, but some loss of colour due to waterlogging is reported from many areas. The small areas of autumn-sown *barley*, *oats* and *rye* are generally strong and healthy, but some yellowing is reported.

Beans have wintered well and are a satisfactory crop.

Potato planting and sugar-beet

Except on lighter soils, the wet condition of the land hindered preparations for potato planting. Some progress was made with the planting of early varieties, but generally work is in arrears.

The preparation of land for sugar-beet is less forward than usual, but sowing has begun on light soils in several areas.

Potato stocks

Potatoes have kept well in stores and clamps, but considerable sprouting has occurred in most areas.

Pastures

All *leys* are forward in growth and in good condition, but many fields were too wet to graze without poaching.

Permanent pastures made good growth and are generally forward, but grazing has been limited in many districts owing to the wet conditions. Some winter-grazed pastures have been badly poached.

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